POWER

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Stuck on the Center

I OCCASIONALLY receive letters from engineers who do not feel that they have made the success of it that they should have done.

They are written usually in connection with some question of wages and come from men of the wage-earning rather than the salaried class.

There are individual cases where faithful, interested, intelligent service has resulted in savings compared with which the pittance paid for it is miserably meager.

This is usually the case of the man who, while really the head of the power department, has allowed himself to be kept along in his relations to the business and to the owner or management on the basis of so much a day.

If he makes real savings or improvements in the running of the department and sees that the management knows of it; if he points out sources of saving or improvement the reality of which can easily be made apparent or which can be tried out with little investment and expense; if he is able to discuss intelligently the cost, condition and affairs of his department with his superiors—he will become a recognized department head and find that the reason that he was slighted before was because they did not know about him.

Then there is the collective case of the power-plant operative, the man whose activities are largely repetitive, manual, mechanical; requiring promptness and some degree of skill, but done under direction and involving or permitting of no assumption of responsibility, planning or self-direction.

Such positions are simply stepping stones to something better. There is no good reason why they should pay higher wages than positions requiring an equal amount of skill and offering similar conditions of personal comfort and security in other lines. Most successful power-plant engineers have come up out of this stratum. It was their training school, but they had to make it so and treat it as such.

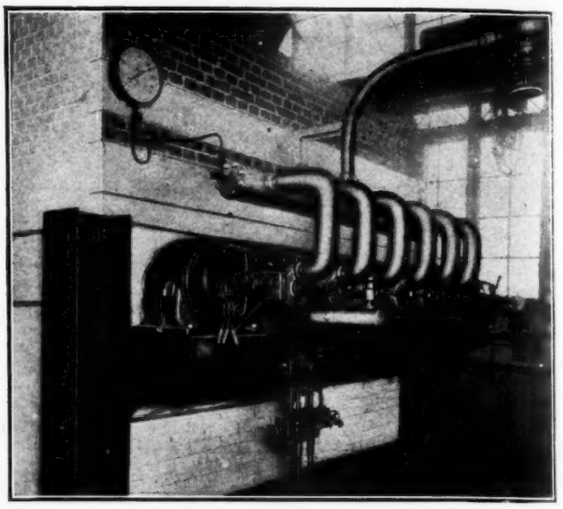
Some of the letters from men who have failed to advance would indicate by their character, entirely aside from their contents, that their authors were not in the winning class.

It has been our privilege occasionally to put men and jobs together. It is a triple benefit—a favor to both of the contracting parties and a pleasure to us. We know of men who are doing good work that is not appreciated or who have reached the limit of their present positions. If those who can appreciate this kind of service, who realize that there are savings to be made and are willing to share such savings with the man who makes them, will indicate such willingness, we will see that they get the man.

F. R. Low

Swedish Boiler Operates at Pressure of 1,500 Pounds

By EDVIN LUNDGREN
Consulting Engineer, Stockholm, Sweden



AMONG the other sensational features of the Atmos boiler are steam generation from centrifugally formed shells of water in rotating tubes of 12 in. diameter and an evaporation of 60 lb. of water per hour per square foot of steam-making surface.

THE higher thermal efficiency obtainable in steam engines and turbines by the use of steam of higher pressure has been clearly recognized by all who have studied the question. Whether figured on the basis of the Carnot, Rankine or any other reasonable cycle, an increase of pressure always shows a considerable increase in efficiency. It is not difficult to find conditions where an increase of the initial pressure from 300 to 1,500 lb. per sq.in. would increase the power obtained from a given weight of steam by from 20 to 60 per cent and, in the case of back-pressure engines or turbines even 100 per cent or more.

Fig. 2 shows how large are the savings made possible by the use of high-pressure steam, particularly in the case of back-pressure prime movers. In this diagram, N_1, N_2 and N_3 denote the brake horsepower that may be obtained from 1,000 lb. of steam per hour during its expansion from an initial pressure of 1,500, 300 and 220 lb. (gage) respectively down to various back pressures. In all three cases it has been assumed that the steam in its initial state had the same heat content of 1,370 B.t.u. per lb. The curves t_1, t_2 and t_3 indicate the respective temperatures of the exhaust steam leaving the prime mover, while t_s is the temperature of saturated steam at the various exhaust pressures.

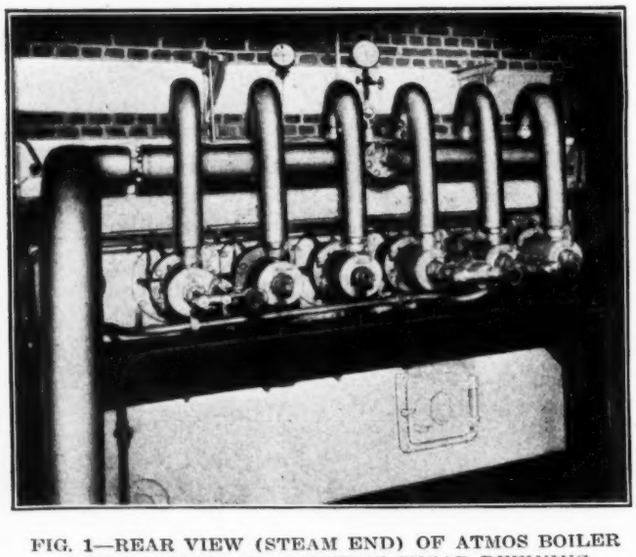


FIG. 1—REAR VIEW (STEAM END) OF ATMOS BOILER INSTALLATION AT CARNEGIE SUGAR REFINING WORKS, GOTENBURG, SWEDEN

The picture clearly shows the steam connections to the six rotating tubes. This boiler has been in continuous daily service for more than a year, carrying a steam pressure of 900 lb. per sq.in. At the top of the page is a view of the front of the same boiler. This shows the motor which rotates the tubes at 330 r.p.m. by means of gears attached to the ends where the feed water enters.

On account of the lower initial superheat and the greater work done in expansion, it is easily understood that the exhaust steam from a turbine using the high-pressure steam is less superheated (or, if saturated, has a lower quality) than that of a turbine with a lower initial pressure. However, if the exhaust steam is to be used for industrial heating purposes, this may frequently be an advantage.

That, wherever possible, steam in its higher pressure ranges should be used for generating power in back-pressure engines and turbines, and the exhaust steam from the prime movers used for industrial heating purposes, is more and more realized by steam engineers. A glance at Fig. 2 shows the importance of high initial pressure when back-pressure turbines are required to deliver much power.

In recognition of its advantages the modern trend has been steadily toward the application of higher pressures. This has undoubtedly helped to make the water-tube boiler predominant in the larger modern steam plants. Certain difficulties, however, as well as safety considerations, have prevented the general adoption of pressures higher than 350 lb., at least in stationary practice. The recent use of 400 lb. in the new central station of the Public Service Company of Northern Illinois at Waukegan and 550 lb. at the Philadelphia plant of the Ohio Power Co. are exceptions that indicate the trend of modern power-plant design.

In smaller boiler sizes attempts have been made, by De Laval, Herreshoff, Serpollet, White and others, to produce steam at higher pressures. In most of these cases spiral tubes of a small diameter were used, through which the water was forced. The small diameter of the tubes allowed small thicknesses of the tube walls—a favorable condition for heat transmission. Moreover, the danger in case of an explosion was greatly reduced on account of the small water content of the tube. On the other hand, it is evident that the removal of sediment and harder incrustations from the inside walls of the small tubes is a difficult if not impossible task. Such scale incrustations might easily cause a local overheating of the tubes with disastrous consequences.

There is another factor which, although it has not received much attention, plays an exceedingly important part in the proper service of a boiler, particularly a high-duty boiler. This is the fact that the heat transmitted through the tube walls is far more effectively carried away by water than by steam. In boilers of the ordinary design, equipped with either straight or spiral water tubes, it is, however, practically impossible to keep the inside surface of the heated tubes steadily in contact with the water. On the contrary, the steam generated tends to linger at or near the walls in the form of bubbles, thus increasing the resistance to the flow of heat from the walls. This is, of course, more serious the higher the temperature of the fire and the higher the pressure (and hence the temperature) of the steam produced.

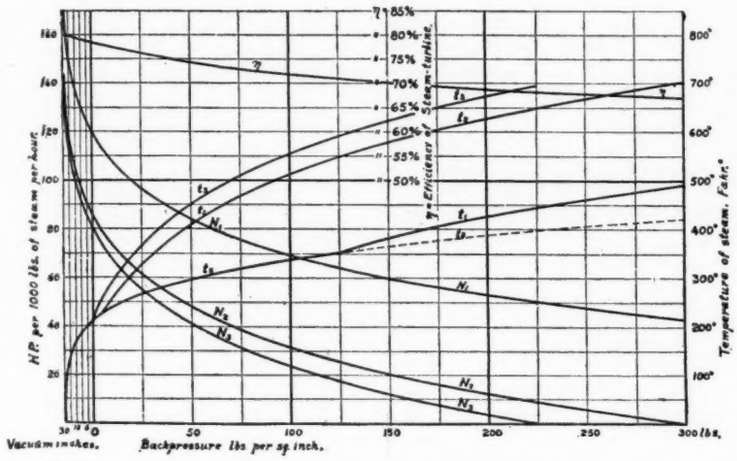

η = Efficiency Steam-turbine.
HP. per 1000 lbs. of steam per hour.
Temperature of steam. Fahr.°
Vacuum in inches.
Backpressure lbs per sq inch.

FIG. 2—DIAGRAM SHOWING EFFECT OF INITIAL AND FINAL PRESSURES ON POWER DEVELOPED

The curves N_1, N_2 and N_3 show the power developed expanding 1,000 lb. (weight) of steam to various back pressures, where the initial pressure is 1,500-lb. gage for N_1, 300 lb. for N_2 and 220 lb. for N_3. In each case the initial superheat is such that the total heat of the steam is 1,370 B.t.u. per pound. The curves t_1, t_2 and t_3 give the exhaust temperatures corresponding to N_1, N_2 and N_3. Both sets of curves are figured on the basis of the Rankine efficiencies given by the curve marked η.

Careful consideration of this factor has led J. V. Blomquist, a prominent Swedish engineer, to design a new boiler on entirely original and daring lines. The principal feature of Mr. Blomquist's design, called the Atmos boiler, is that the steam is generated in rapidly revolving tubes. This rotation results in the inside circumference of the tubes being entirely covered by a shell of water which is pressed against the walls by centrifugal force. This, in turn, forces the steam bubbles rapidly from the walls into the open central space from which the steam passes out through a central tube of smaller diameter. The diameter of the rotating tubes is made as large as the pressure will permit without requiring an excessive wall thickness.

Moreover, the construction is such that the rotating tubes, or the "rotors," as the inventor calls them, may expand freely without strain. In ordinary boilers, it is impossible to avoid those stresses, and it is even impossible to determine them accurately.

The effective cooling of the rotor walls and the freedom from expansion strains make possible rates of evaporation as high as 60 and sometimes even 100 lb. of water per hour per square foot of heating surface. This makes for an exceedingly compact construction.

How the solution of the underlying problem is carried out in practice and a reliable boiler for extremely high working pressures is obtained is best explained by referring to the accompanying drawings and photographs, from which it will be seen that the design embodies a number of rather ingenious features.

The headpiece and Fig. 1 show photographs of an actual installation of which more will be said later.

Fig. 4 shows the general arrangement of a double boiler in plan, elevations and various sections. Each of the two boilers is calculated to generate about 16,500 pounds of steam per hour at 1,500 lb. pressure and 100 deg. superheat (total temperature 700 deg.) and is provided with eight rotors which have an outside diameter of 1 ft. and $\frac{3}{4}$-in. thick walls. The length of the parts of the rotors directly exposed to the heat of the fire is about 11 ft. 2 in. The total heating surface of each boiler is thus 280 sq.ft. As Fig. 3 shows, the rotors extend through the brickwork and are supported in bearings, which in turn are carried by a frame of structural steel. A bracket attached to this frame supports an electric motor of 8 hp. which drives (by means of spur gears) all the rotors at a speed of 330 r.p.m.

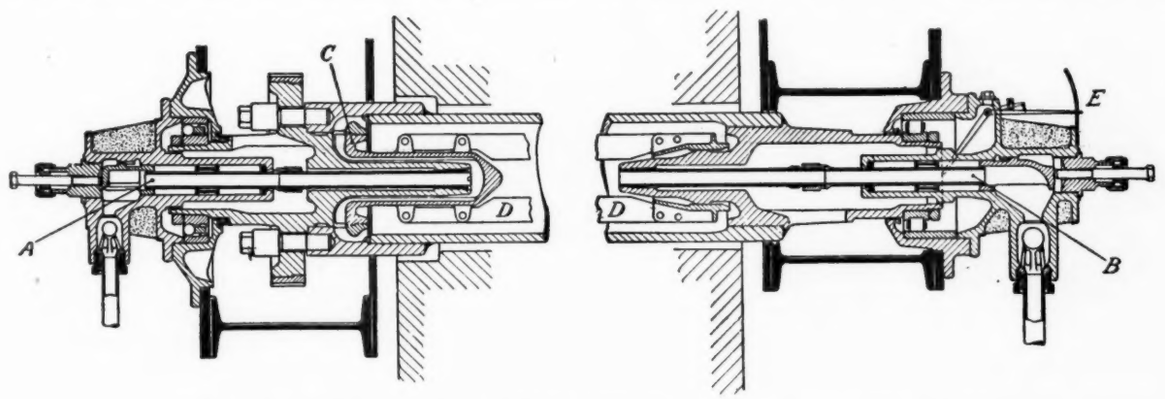


FIG. 3—SECTION THROUGH A ROTOR, SHOWING FEED CONNECTION (LEFT) AND STEAM CONNECTION (RIGHT)

In the design shown, the flue gases, after passing the rotors, are first utilized to heat the superheaters *D*, then the high-pressure water economizers *G* and, finally, the low-pressure economizers *H* in order thereafter to

escape into the chimney at a temperature of 350 to 400 deg. F., corresponding to a boiler efficiency of about 80 per cent.

The feed water at 150-lb. pressure is forced by a centrifugal pump through the low-pressure economizer into a settling tank where the scale-forming elements in the water are precipitated. This is, of course, not strictly a feature of the Atmos boiler, as any other method of softening the feed water may be employed.

A multiple-plunger pump delivers the water through the high-pressure economizer to the rotors. On its way to the rotors the water passes a steam separator which leads any steam that may possibly have been formed to a steam collector in the rear of the boiler.

The rotors form the most important part of the new invention, and their design is therefore of considerable interest. Referring to Fig. 3, the hot feed water is admitted through the vertical pipe at the left end to the cover of the stationary bearing housing or shield and enters the rotating part at *A* in the central pipe shown, which has an outside diameter of 1½ in. and revolves in a stuffing box. To keep the packing tight against the pressure of 1,500 lb. and simultaneously avoid excessive friction, is of course a serious problem which many practical steam engineers will consider apprehensively. This problem has, however, been solved by admitting oil under pressure to the central distance ring which divides the packing longitudinally into two parts.

The packing material itself consists of ordinary packing braids. The stuffing-box gland is formed like a cap with an opening on the lower side and is tightened by a single bolt located in the center of the bearing shield. This packing has proved to be entirely satisfactory during a continuous service of over twelve months and is distinguished by its low friction. The oil consumption for a 12-rotor double boiler amounts to about one pint in ten hours.

The bearing housing on this end of the rotor contains a ball bearing in which the neck of the rotor head revolves. This rotor head is a steel casting and is fastened to the rotor by means of a solid flange on the head, which is kept in place by a number of bolts. To this flange is attached the spur-gear ring which drives the rotor. The head can be readily removed for inspection and cleaning of the interior of the rotor.

The outlet head at the right-hand end of the rotor is screwed into the rotor and then welded to it. The neck of this head, and with it this end of the rotor, is supported by a roller bearing in a manner that allows free expansion and a considerable lateral movement.

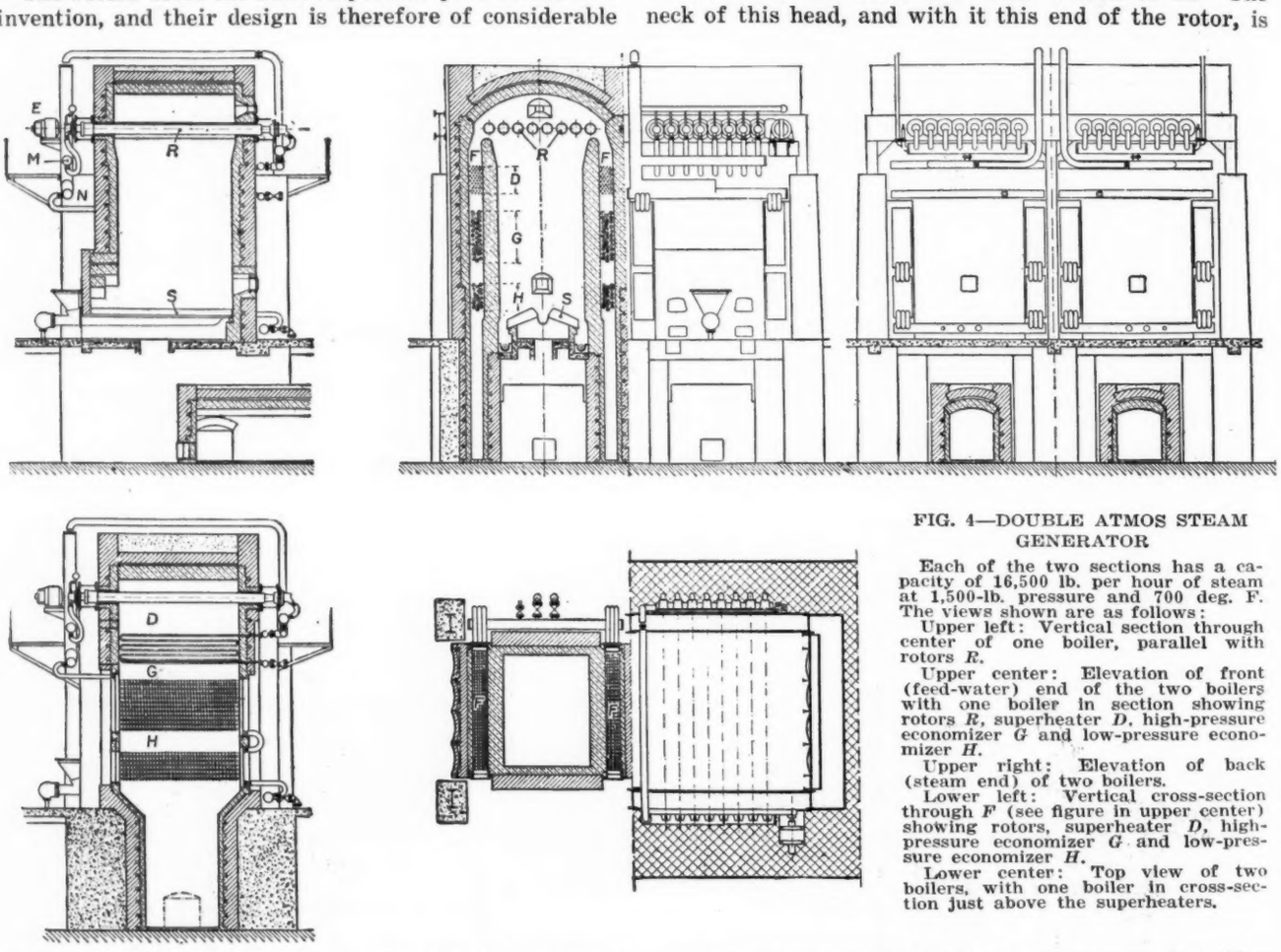


FIG. 4—DOUBLE ATMOS STEAM GENERATOR

Each of the two sections has a capacity of 16,500 lb. per hour of steam at 1,500-lb. pressure and 700 deg. F. The views shown are as follows:

Upper left: Vertical section through center of one boiler, parallel with rotors *R*.

Upper center: Elevation of front (feed-water) end of the two boilers with one boiler in section showing rotors *R*, superheater *D*, high-pressure economizer *G* and low-pressure economizer *H*.

Upper right: Elevation of back (steam end) of two boilers.

Lower left: Vertical cross-section through *F* (see figure in upper center) showing rotors, superheater *D*, high-pressure economizer *G* and low-pressure economizer *H*.

Lower center: Top view of two boilers, with one boiler in cross-section just above the superheaters.

Returning to the inlet end and following the water on its passage into the rotor, we notice that the water leaving the central pipe flows back (to the left) toward the head through the annular space formed by the hub of the head and a surrounding casting. This casting is provided at one end with a flange *C*, slightly larger in diameter than the inside of the rotor and fitted on its face with vanes like the impeller of a centrifugal pump. By this the incoming water is immediately distributed over the whole inner circumference of the rotor. The sheet-iron strips *D* serve to start the water rotating quickly when the rotor is started up.

As mentioned before, the steam generated is collected in the interior of the rotor and escapes through the central steam-outlet pipe (at the right in Fig. 3) which

revolves in a stuffing box of the same construction as that on the water-admission tube.

The chief purpose in designing the flange *C* like the impeller of a centrifugal pump was to furnish means for measuring the thickness of the water shell and keeping it in correct proportion to the required rate of evaporation. On account of the centrifugal action the pressure in the water inlet is less than that prevailing in the steam outlet, the difference depending on the thickness of the water. Small pipes transmit the water-inlet and steam-outlet pressures to the water regulator shown in Fig. 5. The water pressure is transmitted to the inside of a bell *B* which is suspended in a closed casing *A* by means of a spiral spring *D*, the lower edge of the bell being submerged in a mercury seal *C*. The whole regulator, inside as well as outside of the bell, aside from the mercury seal, is filled with cold water. The steam pressure acts on the outside of the shell. The difference between the two pressures acts through the linkage *EKL* to move the needle valve *FG* controlling a bypass from the delivery pipe to the suction line of the high-pressure feed pump.

When the load or the rate of evaporation increases, the thickness of the water body in the rotor decreases, which results in a corresponding change in the differential pressure. This acts on the bell and levers to cut down the bypass flow, thus increasing the flow of feed water to the boiler. The regulator continues to act in this manner until perfect equilibrium is attained. To each load or evaporation there corresponds a certain thickness of the water layer, varying between 1⅛ in. and 2 in. This regulator is stable in its action and the resistance of the needle valve is small. The change of the net force acting on the bell in the two extreme positions amounts to 45 lb. As all rotors are connected, one regulator is sufficient for the whole boiler.

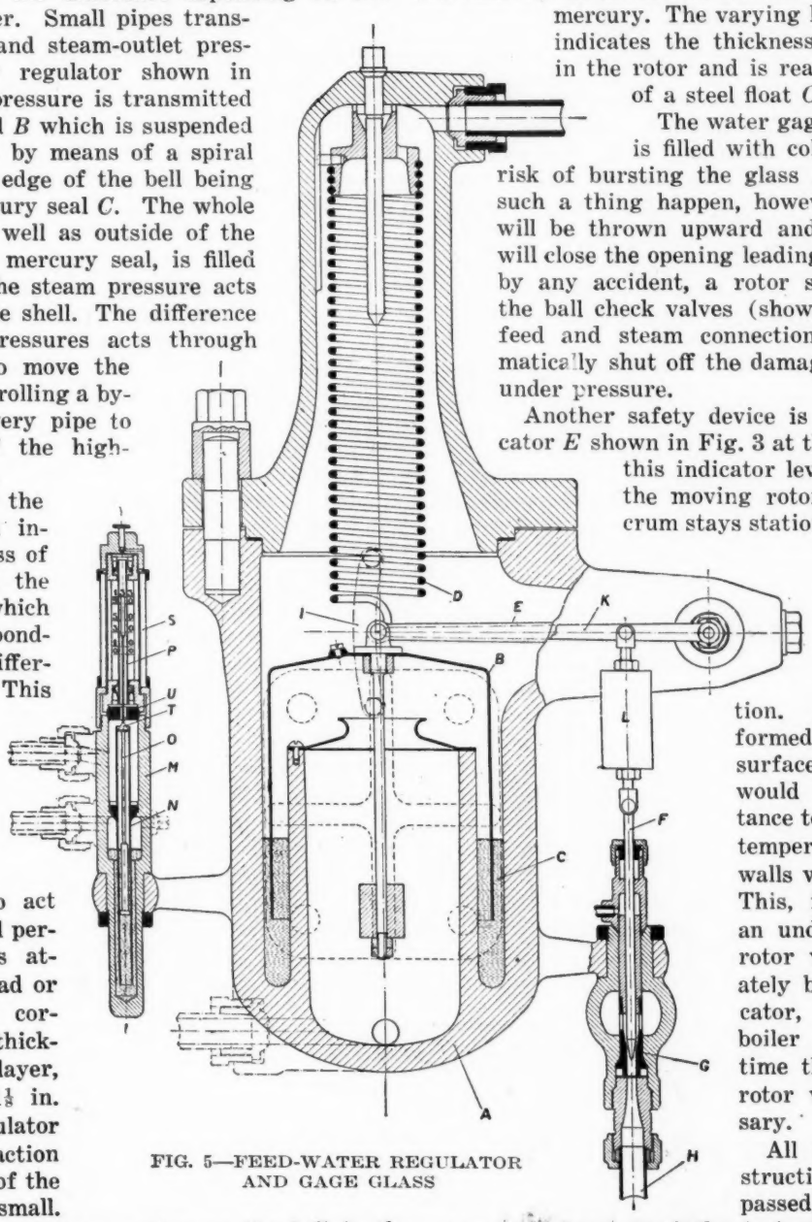


FIG. 5—FEED-WATER REGULATOR AND GAGE GLASS

It is, of course, perfectly feasible to accomplish the water control in some other way; for instance, by influencing the speed of the motor that drives the feed pump.

As explained before, the thickness of the water body in the rotor corresponds to a certain position of the bell. This position may serve as a water gage, as it is easily indicated on the outside of the regulator by an extension of the lever *K*. For the sake of safety and convenience, however, the water is gaged by an independent water gage attached to the regulator housing as shown at the left in Fig. 5. This water gage is operated by the same differential pressure that controls the regulator. The narrow cylindrical casing of the gage is divided into two compartments. The lower one, partly filled with mercury, is connected to the water pressure, while the upper one is connected to the steam. The two compartments are connected by the stationary central tube *N*, the lower end of which is immersed in the mercury. The varying level of this mercury indicates the thickness of the water body in the rotor and is read at *S* from the top of a steel float *O*.

The water gage, like the regulator, is filled with cold water so that the risk of bursting the glass *P* is slight. Should such a thing happen, however, the steel rod *O* will be thrown upward and its tapered seat *T* will close the opening leading to the exterior. If, by any accident, a rotor should fail or burst, the ball check valves (shown at the ends of the feed and steam connections in Fig. 3) automatically shut off the damaged rotor from those under pressure.

Another safety device is the elongation indicator *E* shown in Fig. 3 at the right. One end of this indicator lever is in contact with the moving rotor end, while its fulcrum stays stationary with the bearing housing. If the rotor expands, the outer end of the lever *E* will indicate the exact amount of elongation. If scale should be formed and cover the inner surface of the rotor, it would increase the resistance to heat flow so that the temperature of the rotor walls would rise abnormally. This, in turn, would cause an undue elongation of the rotor which would immediately be shown by the indicator, thus warning the boiler attendants in due time that a cleaning of the rotor would soon be necessary.

All the devices and constructions described have passed the first experimental stage and have stood the test of actual service. The headpiece and Fig. 1 show views of the first experimental installation located at the Carnegie Sugar Refining Works, at Gotenburg, Sweden. Here the steam is generated at a pressure of 900 lb. per sq.in. The boiler has been in continuous daily service under rather unfavorable conditions ever since December, 1921, and has given entirely satisfactory results.

Don't forget to close the valve in the liquid line from the receiver to the expansion coils when shutting down an ammonia compressor that is working alone. If these valves are not closed, liquid will accumulate in the expansion coils and suction line.

Automatic Control for Synchronous Industrial Motor-Generator Sets

DESCRIBES a full automatic-control equipment for a 2,300-volt synchronous motor driving a direct-current generator, which is also automatically controlled by standard apparatus

ALTHOUGH practically all automatic control systems have been made up of groups of apparatus, contactors, relays, etc., that were themselves standardized types, the systems themselves have usually been individually designed to fit the case in hand. The rapid development of automatic station control, together with the operating experience and data that have been accumulated with regard to its requirements and performance, have recently led to the development of a standardized system, as adapted to the control of synchronous-motor generator sets for mining and industrial use.

The advantages of standardized equipment, whether of individual devices or whole systems employing these devices, have become too familiar to need any particular emphasis. The standardized automatic station control developed by the General Electrical Co. is designed to meet the exigencies of service that previous experience have shown liable to arise. Automatic station control equipments for industrial service have been standardized for motor generators having capacities of 100, 150, 200 and 300 kw., at 275 volts direct current, to be operated from 2,300-volt three-phase alternating-current. They are built for operation on either stub-end or combined stub-end and multiple feeder service, automatic reclosing features for both these conditions of service being included in the latter equipment. The standardization of this equipment is, however, not so inflexible but that changes can be incorporated to meet local conditions that may call for a wide variation from the regular type of control.

Since, with few exceptions, mostly confined to the respective automatic reclosing equipments, the control systems for both stub-end and combination stub-and-multiple feeder service are constructed and operate in the same way, a description of the characteristics of the stub-end equipment will serve for both.

A complete equipment consists of a synchronous-motor generator set of the required voltage, the switchboard carrying the control and reclosing apparatus and the necessary transformers, etc. The standard switchboard consists of three panels, one carrying the whole of the automatic reclosing equipment, another the automatic control and protective equipment, and the third the main-line oil circuit breaker, metering instruments, control power switch, etc. The whole board will fit into a space 6 ft. high by 6 ft. deep, by about 5.5 ft. wide. The devices forming the equipment are connected as shown in the wiring diagram, Fig. 2, and their operation is as follows:

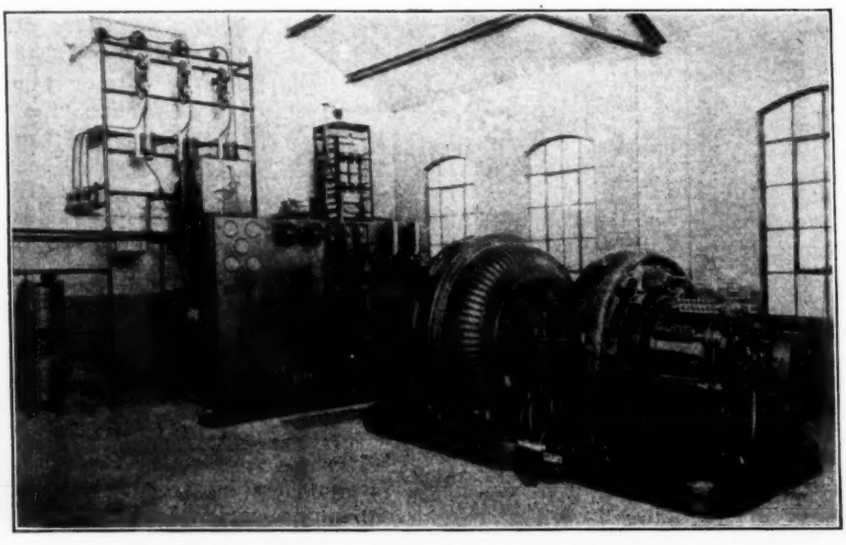


FIG. 1—SYNCHRONOUS-MOTOR DIRECT-CURRENT GENERATOR AND FULL-AUTOMATIC CONTROL

The power to operate the various control devices is obtained from the control-power transformer *P*, which is connected to one phase of the incoming 2,300-volt line. The starting impulse, from whatever source, master element, switch, etc., having been given, with the oil circuit breaker *B* and the control-power switch *S* being closed, the control-current contactor *C* is energized and closes, provided the control circuit through all the protective devices is complete. The closing of contactor *C* closes the starting contactor *A* and starts the synchronous motor. During this time the contacts of the field-building relay *F* remained closed, short-circuiting a portion of the generator shunt-field rheostat and allowing the generator voltage to build up rapidly. At a predetermined setting the increasing generator field voltage causes relay *F* to open its contacts, inserting additional resistance in the generator field.

At about synchronous speed the generator-field relay *G* closes its upper contacts, energizing the synchronous-motor field contactor *M*, causing it to close and put field on the motor. Direct-current field relay *E* then operates, breaking the coil circuit of starting contactor *A*, opening it and closing the coil circuit of running contactor *R*, causing it to close. When contactor *R* has closed, one of its auxiliary contacts energizes time-delay closing relay *T*, on the automatic-reclosing panel, which closes its contacts after a definite time delay. If no short-circuit, or other abnormal overload condition exists on the direct-current feeder, reclosing relay *D* will close and energize the coil of line contactor *L*, which closes, putting full voltage on the direct-current feeder, if the line switch *H*, on the automatic-reclosing panel, is closed.

The station is shut down when the control contactor *C* is de-energized, either by opening the master starting

element or by the operation of any of the protective devices in the control circuit. Upon the opening of contactor *C* all the control devices will return to their starting position. It might be explained that the protective operation of the automatic reclosing apparatus does not affect the continued running of the motor-generator set; it merely disconnects the load from the generator.

One of the important features of the equipment is the thorough protection afforded the motor-generator set, either from damage due to trouble arising in the machines themselves or from abnormal conditions either on the alternating-current supply or at the load on the direct-current feeder. Continuity of service at the load is just as important, however. This is insured by the operation of the automatic reclosing equipment. Protective equipment may, therefore, for purposes of convenience, be considered as divided into classes according to function, the control protective system and the feeder protective system. To go into the details of the former would be needlessly tedious; its completeness can be shown by a simple enumeration of the devices and their functions.

Overload on the motor opens the overload relays *O*, in the coil circuit of the oil circuit breaker *B;* undervoltage operates relay *J* in the control circuit; this relay and relay *K* also prevent connection to the alternating-current line when single-phase conditions exist. Loss of excitation shuts the station down through field relay *E;* a polarized relay *P'* prevents the machine from being connected to the line with wrong polarity.

In case of overspeed the speed-limit device *N* opens and causes control contactor *C* to open, shutting the station down. Bearing thermal relays *Q* open the control circuit of contactor *C* when the bearings become overheated. These relays are hand reset and require the presence of an inspector to get the station running again. Machine thermal relays *U*, connected to current transformers and having a thermal characteristic similar to that of the machine windings, prevent damage from running with overheated windings. If for any reason, after the starting sequence has begun, the running contactor fails to close, the compensator will heat up and cause compensator temperature relay *V* to open, breaking the circuit to the control contactor *C* and shutting the station down. Relay *V* must be reset by hand. An oxide-film lightning arrester *LA* and choke coils *CHC* guard against damage from lightning.

The method by which the automatic reclosing equipment insures continuity of service and yet protects the station equipment from damage due to abnormal conditions on the feeder, is comparatively simple. When a short-circuit or heavy overload occurs on the feeder, the contacts of the instantaneous overload relay *I* are opened, which de-energizes line contactor *L* and disconnects the load from the generator. The coil of the

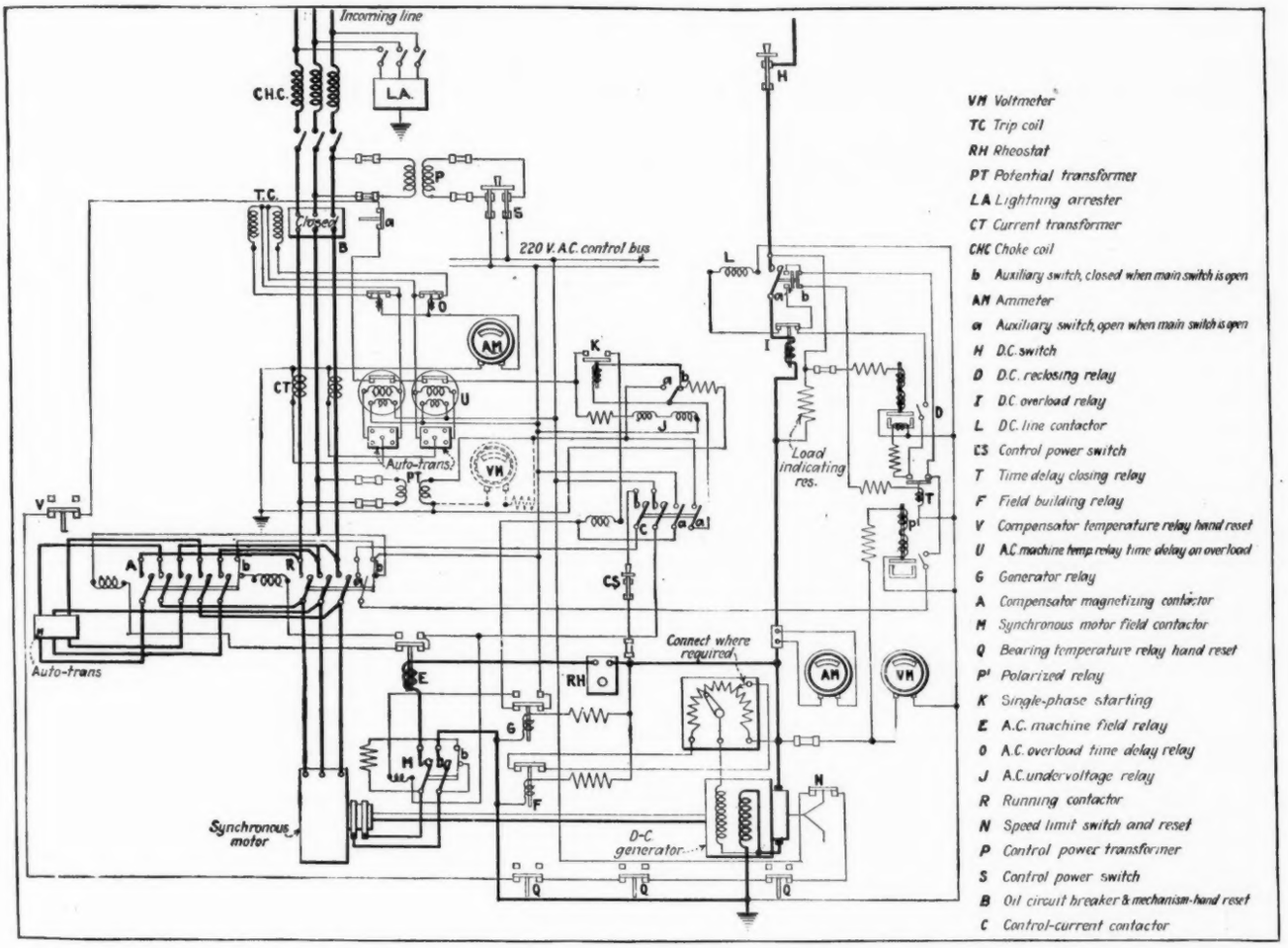


FIG. 2—WIRING DIAGRAM FOR SYNCHRONOUS-MOTOR DIRECT-CURRENT-GENERATOR FULL-AUTOMATIC CONTROL

time-delay circuit-closing relay *T* is then energized through an auxiliary contact on contactor *L* which closes when the latter opens. Relay *T*, thus energized, will close its contacts in a definite time. The load-indicating resistor remains connected across contactor *L*, to furnish a reliable means of measuring the resistance of the load in terms of the voltage drop across it. When the short-circuit is removed or the overload is reduced to a predetermined value, the voltage across the load is raised. This causes reclosing relay *D* to operate and close feeder contactor *L*, provided that relay *T* has closed its contacts. Until the voltage across the load has risen, however, the reclosing relay will not operate; in other words, as long as overload or short-circuit conditions exist, the generator will remain disconnected from the load.

The advantages of such a system, especially in mine installations, are pronounced. Mines usually cover a lot of ground, making the supply of power to all parts of them from a central plant rather difficult. By installing an automatic substation or stations at the most convenient points, not only is the voltage kept up to required value in all parts of the mine, but with the automatic-reclosing equipment continuity of service is secured with a minimum loss of time and a maximum degree of safety to electrical equipment.

Effect of Precooling on the Capacity of a Refrigerating Plant

By T. M. GUNN

FOR many years engineers in charge of refrigerating plants were quite satisfied with the condenser operation if the head pressure was within 20 to 30 lb. of the pressure corresponding to the temperature of the cooling water. The ammonia liquid was allowed to leave the condenser at the liquefying temperature. Often this was much above the temperature of the cooling water. In an attempt to reduce the liquid temperature, as well as for other reasons, counter-current, double-flow and flooded condensers were introduced. While all these may work satisfactorily, the lower limit to the cooling of the liquid ammonia still remained at from five to ten deg. above the temperature of the coldest water. Methods were then introduced by which increased precooling is obtained by using a colder water or even ammonia.

While one of the simplest ways in which improved economy can be obtained in the plant is by precooling the liquid ammonia, it should be understood that precooling of liquid is a broad subject. It should be considered not only from the viewpoint of its influence on the plant economy and on the capacity of the evaporating coils, but also on the basis of its cost and of the incidental losses that may be the result of the method used. This cannot all be covered in the scope of this article, which will therefore be confined to the direct influence of liquid precooling on the amount of refrigerating effect that is obtainable from a compressor of a given size and on the horsepower per ton.

In order to study precooling independently of the complicated conditions that are sometimes involved with it, we will consider only one type of plant, in which the liquid ammonia leaves the condenser at the same temperature as that at which condensation takes place. We will assume that the liquid is then cooled by means of a small water supply which is colder than the condenser water. What is the effect on the capacity of the plant?

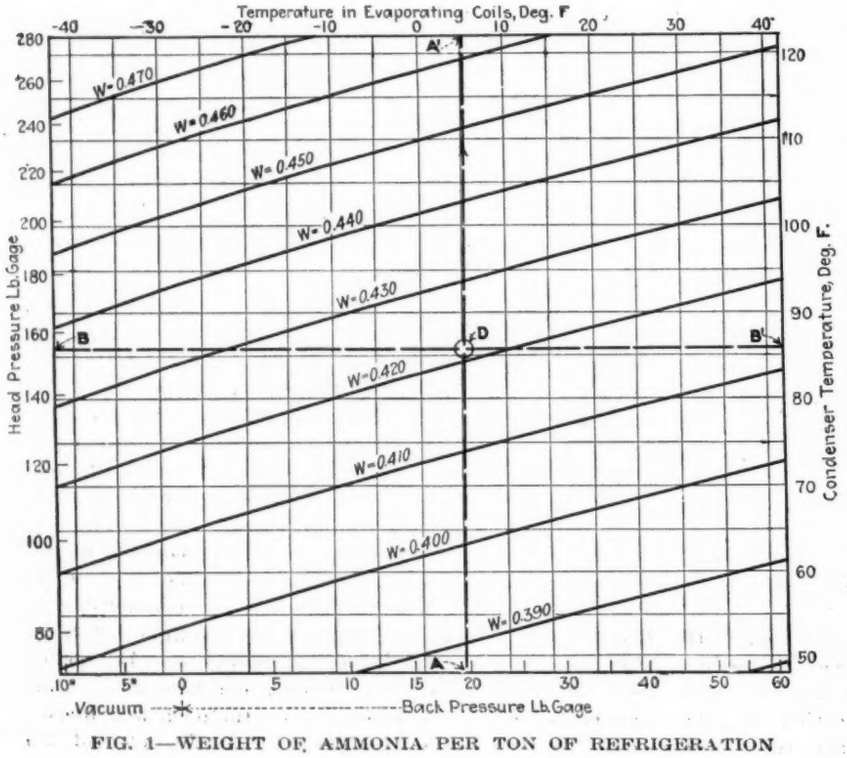


FIG. 1—WEIGHT OF AMMONIA PER TON OF REFRIGERATION

The answer is simple. Under these conditions the refrigerating effect is increased by the same number of heat units as are removed from the liquid ammonia in the precooler. Every 200 B.t.u. per minute removed from the liquid in the precooler increases the rate of refrigeration by one ton per 24 hours. Let us explain the reason for this:

Each pound of liquid ammonia passing the expansion valve contains a certain number of heat units. Call this *A*. When the same pound of ammonia leaves the cooling coils on its way to the compressor, it contains a greater number of heat units. Call this *B*. The difference (*B* — *A*) is the heat that this pound of ammonia has absorbed; that is, it is the refrigerating effect in heat units due to that pound.

If the liquid is precooled before it goes to the expansion valve, its heat contents, which we have called A, will be less by the amount of the heat removed, and the refrigerating effect (B — A) will be greater than before by the amount that A was decreased, which proves the statement of the preceding paragraph.

Charts that show the capacity and horsepower per ton obtainable according to the theoretical cycle of ammonia refrigeration, assuming that there is no precooling of the liquid ammonia before it goes to the expansion valve, were published in *Power*, Feb. 6, 1923. This cycle was referred to as a performance scale by which plant performance might by compared.

If additional refrigeration can be secured cheaply by precooling, it is worth while in every plant to investigate the possibilities carefully. To show the results of studying this from a theoretical viewpoint, the chart in Fig. 2 was computed. It shows the gain over the theoretical cycle described in *Power*, Feb. 6, 1923, and may be used conveniently in connection with the charts there given.

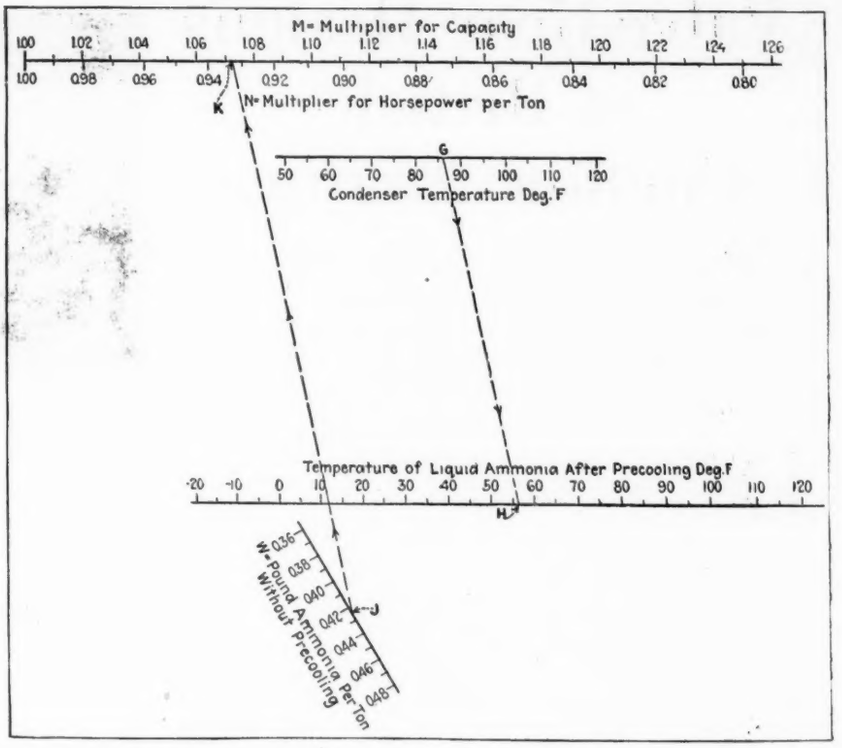

M= Multiplier for Capacity
100 102 104 106 108 110 112 114 116 118 120 122 124 126
100 098 096 094 092 090 088 086 084 082 080
K
N= Multiplier for Horsepower per Ton
G
50 60 70 80 90 100 110 120
Condenser Temperature Deg. F
Temperature of Liquid Ammonia After Precooling Deg.F
-20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120
H
W= Pound Ammonia Per Ton Without Precooling
036 038 040 042 044 046 048
J

FIG. 2—EFFECT OF PRECOOLING UPON CAPACITY AND HORSEPOWER

To use the chart in Fig. 2 it is necessary that one know the temperature of liquid leaving the condenser, the temperature to which the liquid is precooled, and approximately the number of pounds W of ammonia passing the expansion valve per minute per ton refrigeration. The last figure W can be found from the chart in Fig. 1, where by following the vertical line AA^1 corresponding to the back pressure until intersection is made with the line BB^1 corresponding to the head pressure, the point of intersection D enables the weight to be read from the diagonal line. In the values used in the chart W is seen to be close to 0.422 pound.

As an example, suppose that the head pressure is 154 lb. gage, for which the corresponding liquid temperature is 86 deg. F., and that the liquid is precooled to 56 deg. F.; also that 0.421 lb. of ammonia passes the expansion valve per minute per ton. It is of course impossible to obtain 56 deg. precooled ammonia unless the cooling water be around 46 to 50 deg. Such water temperatures occur only during the winter months except under exceptional circumstances; however, this is not of any consequence as far as using the chart is concerned, since it only affects the results and not the application.

Find the point G, on the chart, Fig. 2, for a condenser temperature of 86 deg. F., and the point H for 56 deg. F. after precooling, and draw the line GH. Find the point J for 0.421 lb. of ammonia per ton, and draw the line JK, parallel to GH. The results are read at the point K, where the multiplier for capacity is seen to be 1.072, and that for horsepower per ton, 0.933.

If this compressor can develop 200 tons refrigerating effect without precooling, then by precooling from 86 deg. F. to 56 deg. F., the refrigerating effect would become as follows:

$$200 \times 1.072 = 214.4 \text{ tons}$$

The horsepower per ton of refrigeration becomes less because the refrigerating effect is increased without any change in the actual work of compression. For instance, if the horsepower per ton without precooling is 1.5, then with precooling, it becomes

$$1.5 \times 0.933 = 1.4 \text{ hp. per ton}$$

As intimated before, this discussion has brought out only the direct gain in refrigerating effect through precooling. There are other benefits derived from this, and, on the other hand, there are sometimes losses or cost items that enter into the problem which may even make precooling undesirable.

Steam Pump Nomenclature

When one is called upon to purchase a steam pump but seldom, comparing specifications of the several bidders may be difficult by reason of lack of familiarity with pump nomenclature. There are so many trade terms applied to power-plant equipment that unless one is in touch with them all the time it is difficult to even know of their existence, let alone their meaning. An explanation of a few pump terms are as follows:

Regularly Fitted—A pump is said to be "regularly fitted" if it is provided with a cast-iron water plunger working in a bronze ring or a cast-iron piston working in a brass liner. The piston rods are of steel, while the water valves and valve seats are bronze, unless rubber valves are called for.

Brass Fitted—A "brass fitted" pump has a tobin bronze piston rod. The water plunger is either solid bronze or has a brass bushing over the cast-iron core. The stuffing boxes and glands on the water end are of bronze or brass.

All Iron Fitted—To handle liquids which attack brass or bronze but not cast iron, pumps are "all-iron fitted." All parts are made of cast iron or steel.

Acid Proof—To handle highly corrosive acids, the entire liquid end must be lead-lined or wood-lined or made of some acid-resisting alloy. Such pumps are termed "acid proof."

Valve-Gear Designs of British Unaflow Engines

THE general lines of the unaflow engine have become fairly well established and it is only in the valve gearing that the designer can call his individual ideas into play. Consequently as this discussion shows British unaflow engines have as varied valve gearing as have American engines.

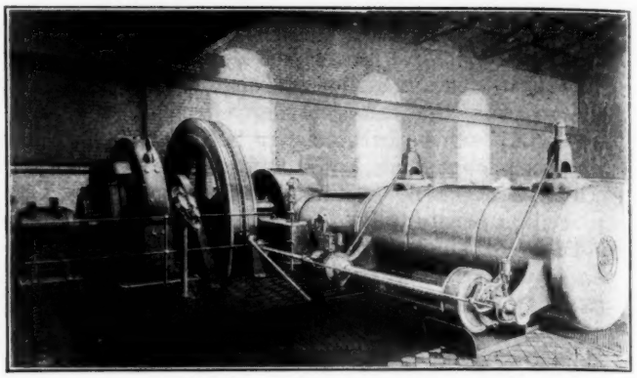


FIG. 1—ROBEY UNAFLOW ENGINE

DURING the last two years the unaflow engine has had a good deal of attention bestowed upon it by British engineers, some of the leading steam-engine designers in the country having taken up the question. Moreover, the leading builders of the slow-speed steam engine have made arrangements among themselves to investigate the whole matter of unaflow engine design and performance from a collective viewpoint. Engine designers are by no means convinced that the all-electric age has arrived or that the steam engine has ceased to be a serious competitor to the large turbo-generator central station. They hold, and no doubt rightly so, that there is still a wide and useful sphere of application for the steam engine of moderate horsepower provided that such an engine possesses a satisfactory steam economy and is not needlessly expensive to construct. The unaflow engine would appear to satisfy these conditions.

Simplicity of Robey Engine

Fig. 1 is a view of the Robey engine direct-coupled to a generator. The simplicity of the engine is particularly noticeable. The main frame consists of a bedplate of the double-bearing type, the trunk guide being cast solid with the bed to insure accurate alignment. The crankcase is enclosed and forced lubrication is applied

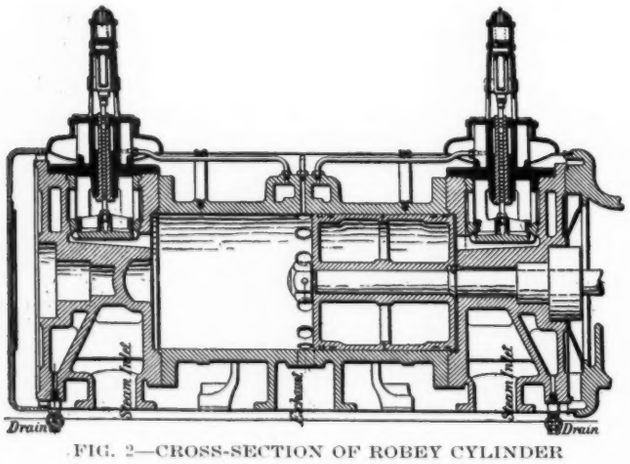


FIG. 2—CROSS-SECTION OF ROBEY CYLINDER

to all the bearings. The cylinder, a cross-section of which appears in Fig. 2, is a one-piece casting with a central exhaust belt. The valves are in the cylinder heads, which are steam-jacketed by the live steam.

The Robey valve gear is shown in Fig. 3. It will be seen that the seat in which the valve works is a cage, an entirely separate casting from the cylinder, and is held in position in the cylinder by the bonnet cover. The cage and the recess in which it fits are accurately tooled to gages. A soft copper ring is let in so that no jointing material is required, and the cage can be removed and replaced at any time with the greatest ease. The spindle actuating the valve is attached to a bridle having at the top a plunger working in the bonnet housing. The

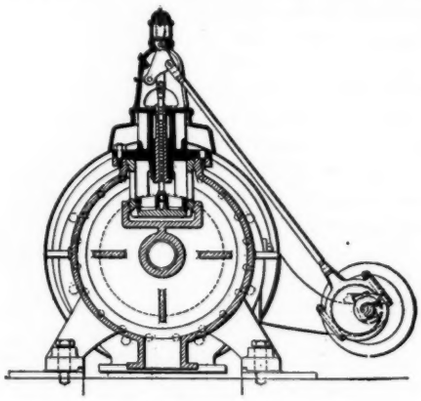


FIG. 3—VALVE GEAR OF ROBEY UNAFLOW

eccentric rod is attached to a cam lever, which is fulcrumed on the bonnet housing and has a cam surface in contact with the roller on the valve plunger.

Ample relief valves are most essential, while some form of automatic supplementary exhaust is necessary for economical non-condensing operation. Fig. 4 shows the relieving device used by the Robey unaflow engines. This device consists of a small valve *A* in each cylinder head, operated by a cam *B* to permit a part of the steam to pass to the exhaust to prevent the compression pressure rising above a predetermined limit. The two cams are adjustable on a shaft driven by an eccentric on the engine layshaft. A shifter *D* is provided at the end of the camshaft so that the cam may be moved into contact with the valve roller *E*. The shifter is operated by a piston in a small cylinder *F* having one side in communication with the exhaust belt and provided with a spring. When there is a poor vacuum or exhaust to atmosphere, the shifter is moved by the spring automatically, and the cams operate the relieving valves; when working condensing, the shifter is pulled out by the vacuum and the valves remain closed.

Figs. 5, 6 and 7 illustrate the cylinder and valve gear of the unaflow engine built by Hick, Hargreaves & Co. This engine differs from the other British unaflows in making use of a valve-controlled central exhaust. This

permits the use of a short piston and cylinder, thereby reducing the frictions and wear of the cylinder walls. As shown in Fig. 6 the steam valves are double-ported and are operated by a detaching or Corliss mechanism; the governor, by moving a detaching lever, alters the point of cutoff in conformation with the load. The exhaust valve is of the solid piston type and is driven through a rocker arm by an eccentric on the layshaft.

To keep the compressor within bounds in case the vacuum is lost, a clearance pocket and relief valve are provided in each cylinder head. This valve has an

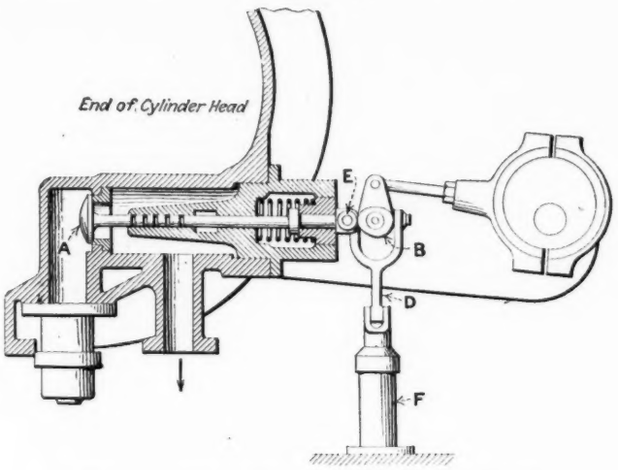


FIG. 4—AUTOMATIC AUXILIARY EXHAUST

outside linkage to enable the operator, by throwing the valve open, to run the engine non-condensing.

An interesting feature of the Galloway unaflow is a patent inspection door, by means of which access into and inspection of the interior of the cylinder are obtained without dismantling. The internal face of the cover and the piston face are polished to reduce condensation losses. The valves are cast iron of the double-beat type and constructed so that any variation in temperature will affect the valve and seat equally, and under high superheats a perfectly steam-tight valve is obtained.

The Galloway valve gear shown in Figs. 8 and 9 is

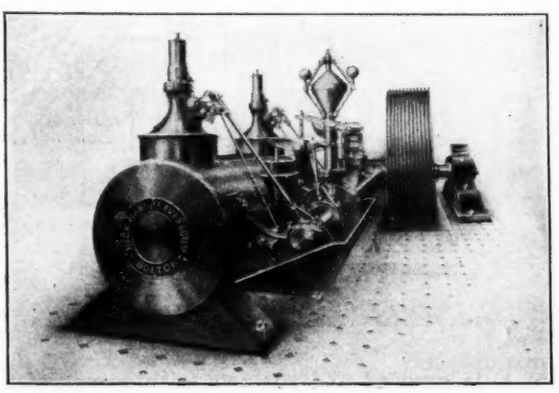


FIG. 5—HICK, HARGREAVES & CO. UNAFLOW

a simple hydraulic mechanism. An eccentric on the layshaft operates the ram *D* of an oil pump arranged in the valve bonnet. The pump ram is hollow and has a ring of slots or ports *E* which at certain parts of the travel may be covered by a sleeve *F* surrounding the pump ram, the axial position of this sleeve being controlled by the governor. On the up-stroke of the pump oil is forced into the pressure chamber below the valve plunger *A*, thus raising the plunger and the steam valve.

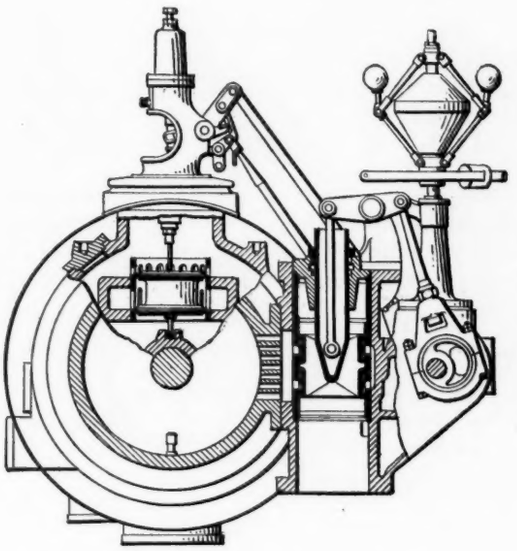


FIG. 6—STEAM AND EXHAUST VALVE GEAR

At a point determined by the position of the governor the ports in the hollow pump ram overrun the sleeve *F* and the oil escapes through the ports back into the oil reservoir *G*. The steam valve is now free to close under the combined action of the spring and the dashpot piston, the seating of the valve being both rapidly and quietly performed.

The Galloway automatic compression release gear is shown in Fig. 10. From the drawing it will be seen that the supplementary exhaust valve *a* is arranged on the side of the cylinder head. The valve, there being

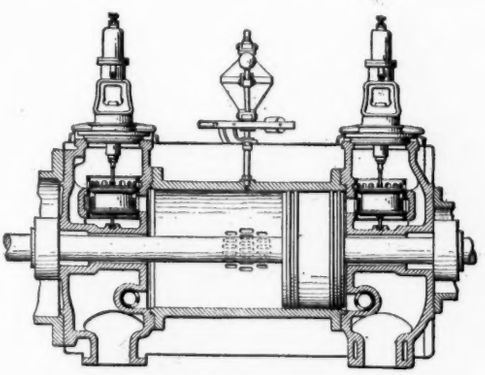


FIG. 7—CROSS-SECTION OF ENGINE

one for each end, opens inward and is kept normally closed by the spring *b*. On the engine layshaft is a sleeve *d* carrying a cam *e* of tapering form, which is capable of longitudinal movement on the shaft. The axial position of the cam is made to correspond automatically with the vacuum in the condenser by a spring-controlled piston *f* of a small cylinder *g* mounted at the end of the layshaft. One end of the cylinder is open to the atmosphere and the other to the condenser. The piston operates the cams by means of the rod *h* and a

key passing through slots in the layshaft. Under normal conditions of vacuum the low part of each cam just clears the roller on the supplementary exhaust-valve stem and the valve remains seated. If the pressure in the condenser rises, the piston in the vacuum cylinder

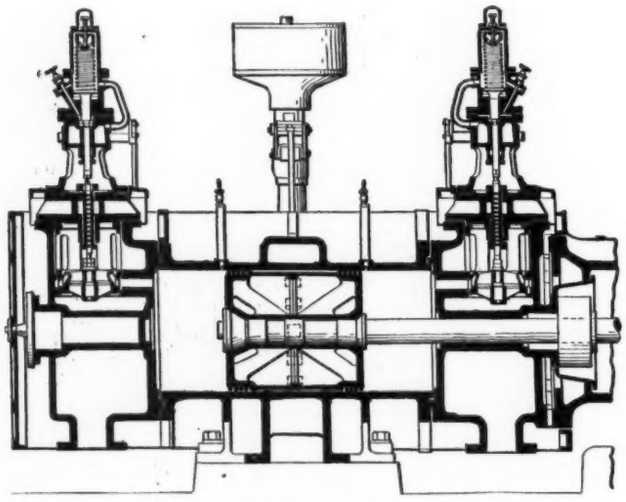


FIG. 8—GALLOWAY UNAFLOW CYLINDER

moves out and by means of the rod h moves the cam axially, so that the high portion of the cam holds the exhaust valve open during a portion of the compression stroke. The amount and duration of the valve opening

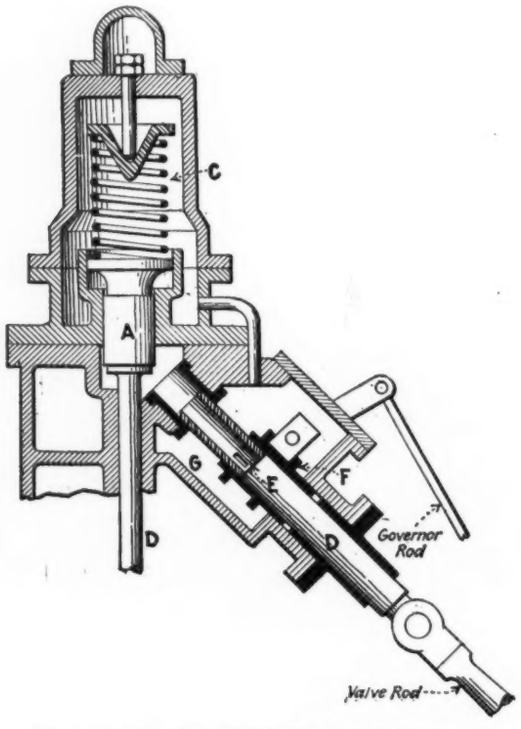


FIG. 9—HYDRAULIC VALVE GEAR USED ON GALLOWAY ENGINE

depend on the axial position of the cams, and thus increase as the back pressure rises.

The Davidson unaflow engine in its general design is quite similar to those already discussed. The frame is of the rolling-mill type with a bearing under the entire bed. The valves are driven by eccentrics which, together with the governor, are mounted upon a layshaft. This layshaft runs along the side of the cylinder and frame and is driven by the crankshaft through bevel gears.

The valve gear of the Davidson unaflow is shown in Fig 8. As will be seen, a bridle A is attached to the

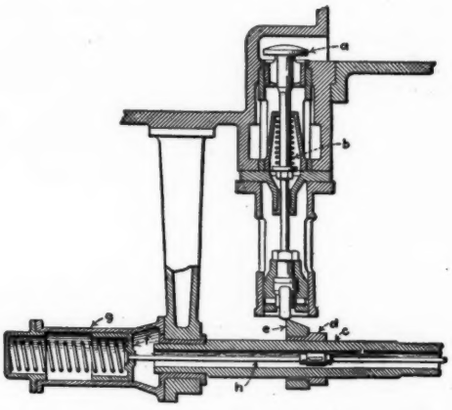


FIG. 10—GALLOWAY AUXILIARY EXHAUST

top of the valve spindle B. This bridle, which is a steel forging, is formed with a cylindrical upper portion C which works in a guide bonnet. A spring D which fits inside this cylindrical portion, serves to close the valve. Lift is by means of the cam E, which is oscillated by the eccentric on the layshaft, the travel being varied by the expansion gear on the layshaft. As will be seen from the illustration, the working edge of the

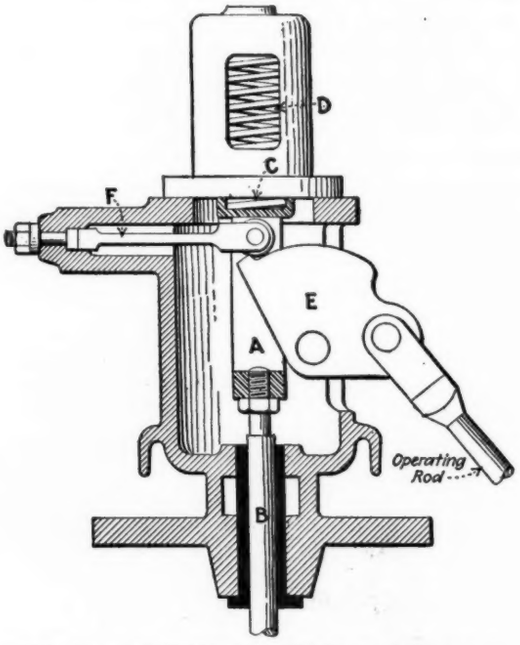


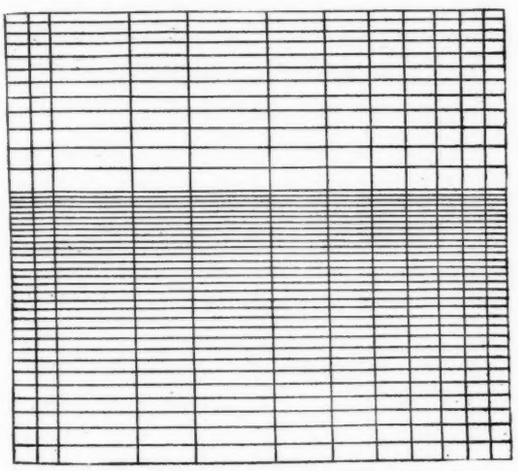
FIG. 11—DAVIDSON UNAFLOW VALVE GEAR

cam E is grooved and contacts with a pair of rollers carried by the spring lever F. A center roller carried by the same lever is in contact with the bridle and is used to lift the valve. The introduction of these rollers prevents any side pressure on the valve spindle due to the operation of the cam, while the introduction of the spring lever F cuts down the number of joints in the mechanism.

A Practical Way To Detect Afterburning in Oil Engines

By H. F. SHEPHERD

SOME years ago J. Paul Clayton, of the University of Illinois, read before the A. S. M. E. a paper on the analysis of steam and internal-combustion engine diagrams. This paper was reprinted in *Power*, June 28, 1912. Though it dealt largely with the steam



IG. 1—LOGARITHMIC CROSS-SECTION PAPER

engine, it touched upon the possibility of applying the analysis to oil-engine diagrams with profit.

Briefly, the method of analysis is this: Compression and expansion lines are transferred from the conventional diagram to logarithmic cross-section paper, Fig. 1 showing this type of cross-sectioning. For internal-combustion engine work the paper is best ruled exactly like the *B*, or logarithmic, scale of a slide rule, both vertically and horizontally. The method of using the scale is shown in Fig. 2, and such charts may be made by any engineer in case the logarithmic paper cannot be purchased from a supply house.

It is the property of this method that curves representing such pressure-volume relations as $P_1V_1^n = P_2V_2^n$ are reduced to straight lines on the logarithmically ruled sheet. It is thus readily observed if the curve should fail to follow its law; that is, if n should vary, the line will no longer be straight but curved. Another advantage of this method lies in the fact that the coefficient n is numerically equal to the tangent of the angle of the logarithmically scaled expansion or compression line with the horizontal.

Transferring the Indicator Diagram

First of all an indicator diagram must be divided by volume and pressure lines as in Fig. 3, which was taken from a solid-injection engine. The clearance volume of the engine must be known accurately. Many diagrams are not good enough for this work, for the reducing motion must be accurate, the instrument without lost motion, and wire instead of cord should be used for the drum cord. The wire must lead directly to the drum, as pulleys introduce fatal errors. It is well to avoid even the lead pulley at the drum. On account of the small diameter of this pulley it often contributes bad errors in spite of the fact that it is part of the instrument. Nothing shows up an indicator to worse advantage than a layout on logarithmic paper.

In transferring two-stroke-cycle engine diagrams to logarithmic paper, it must be borne in mind that compression begins and expansion ends with the closure and opening of the exhaust ports. Beyond the exhaust-port opening line is dead stroke, which has no part in the cycle.

What the Logarithmic Chart Shows

If the points established and set off for the compression line lie well, as in Fig 4, it may be assumed that the indicator work is good and the clearance volume correct. If the expansion line is other than a straight line, it is obvious that during the expansion the exponent n varies; this may be due to afterburning, excessive heat loss to walls, etc. The exponent of the compression line will seldom lie outside of the limits $n = 1.3$ to $n = 1.35$. If it does, error should be sought before the labor of laying off the expansion line is undertaken, as it is possible that the compression volume used is incorrect.

Every operator is familiar with the phenomenon of afterburning. It shows up in reduced economy and lowered capacity in overheated pistons and valves, and in

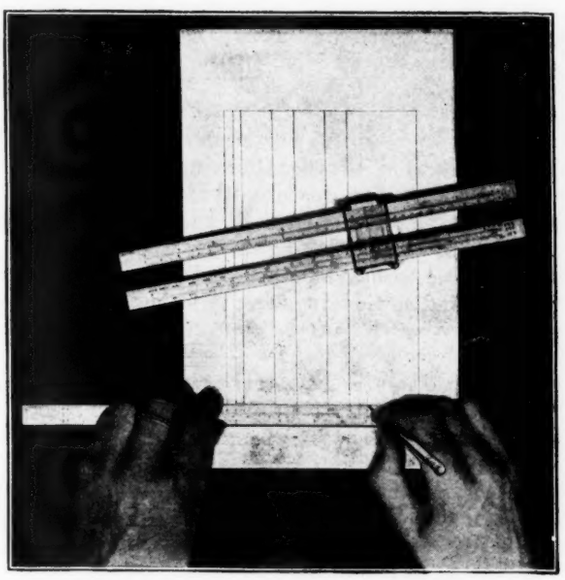


FIG. 2—METHOD OF MAKING CHART BY USE OF SLIDE RULE

smoky exhaust; in fact, it is the general cause of all bad oil-engine operation. An engine is sweet in operation in the degree that afterburning has been overcome. The Clayton method is particularly valuable in investigating this condition.

Figs. 5 and 6 are submitted as "horrible examples" of extreme afterburning. We compress the air in a gas or oil engine to introduce the heat at a high level and in-

crease its fall, so to speak, in order that we may obtain the maximum of the energy of combustion by expansion. In Figs. 5 and 6 we have carried out the function of compression truly enough, but the heat has dribbled in all along the expansion line like steam leaking through a faulty admission valve. Obviously, heat entering late in the stroke has lost a proportional part of its opportunity to do work.

It was the writer's good fortune to be employed upon a double experiment at the time that Clayton's work

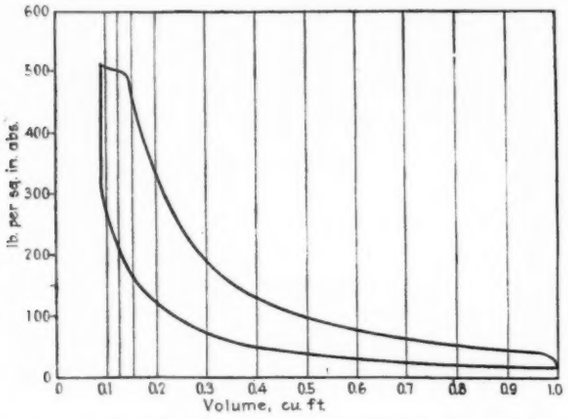


FIG. 3—INDICATOR DIAGRAM DIVIDED BY VOLUME AND PRESSURE LINES

appeared. Similar engines were fitted with solid injection and air injection. The air-injection engine worked on a mixed cycle as follows: Compression to 250 lb. gage, Otto or constant-volume combustion to about 500 lb. gage, a degree of combustion at constant pressure and then expansion. A hot surface was used. This engine developed a most beautiful indicator diagram. Expansion, as was shown by a layout on logarithmic paper, at *g* in Fig. 4, proceeded with the exponent $n = 1.35$.

Expansion Lines of Solid-Injection Engine

The compression of the solid-injection engine was somewhat lower, for reasons that comprise another story. It developed an Otto diagram with a slightly rounded peak. The striking thing was that it never proved possible to develop the solid-injection engine of that model and period to show a better expansion-exponent than $n = 1.19$ to $n = 1.21$, as at *e* and *f* in Fig. 4.

Both engines were two-stroke-cycle, the same cylinders, pistons and driving mechanism were used, the scavenging arrangements were the same, but for air injection n had a value of 1.35 and for solid injection it remained almost unalterably at a mean of 1.20. Fuel at that time was costing as little as sixty cents a barrel. The solid-injection engine won out even though much less efficient than the air-injection engine.

We have learned a lot about solid-injection engines since that time, and fortunately so as fuel prices have advanced, but to this day nobody has produced a Diesel cycle in a solid-injection engine. We have solid-injection Diesels with all Diesel mechanism but the compressor, still they work, without exception, on a mixed cycle. Engines with primary combustion chambers may be excepted, as they are hybrid Diesels, producing air blast by an explosion. In the true solid-injection type we may boost compression to the Diesel value, but any attempt to time solid injection for regulated combustion as may be done with air injection, results in too much afterburning. It is bad, fundamentally, to inject raw fuel into an already burning charge. It must be gotten in quickly, allowed to vaporize under a limited degree of heat and then undergo spontaneous ignition. Any other process results in afterburning. Thus we inject early and sharply, taking as much rise of pressure or constant volume combustion as seems consistent with a safe and practical maximum pressure. By these means an economy slightly lower than 0.4 pound per brake horsepower-hour may be obtained. Needless to say, if the ideal expansion line of the Diesel engine could be produced without the compressor, we would realize the indicated economy of the Diesel engine and a decidedly better brake efficiency. We are approaching perfection of the expansion line, which of itself, even with a mixed cycle, will bring out Diesel efficiencies. It is doubtful if we can ever reach controlled combustion with solid injection.

Desirable Value of the Exponent

Judgment between the cycles is no mere academic matter. High compression is desirable for cold starting, but every designer knows that a safe engine at 650 lb. maximum in working is either a thing of mass or of expensive materials. Therefore, it is the general

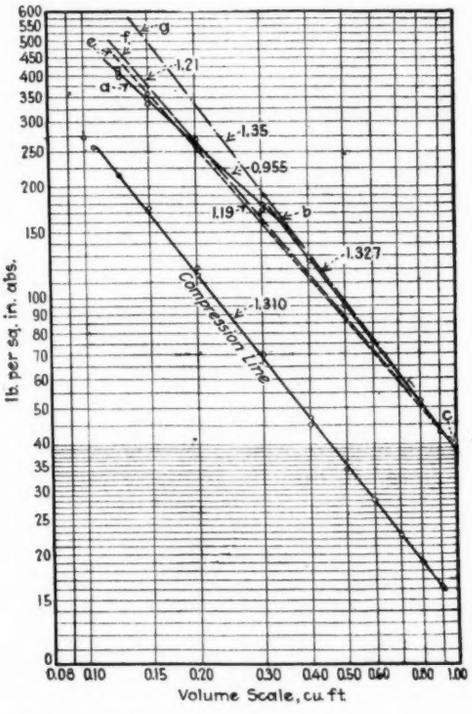


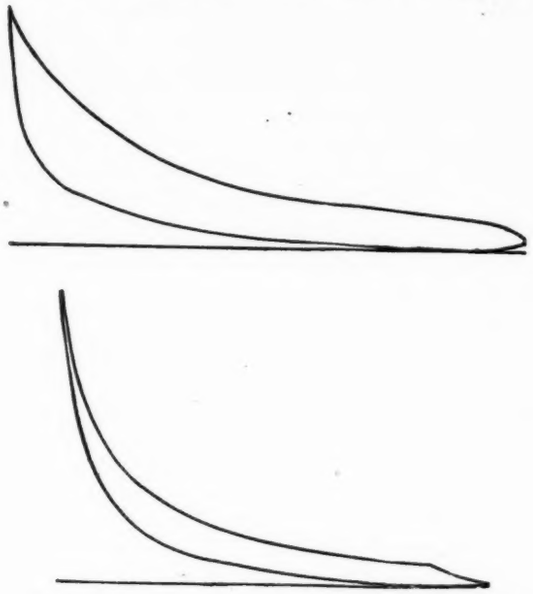
FIG. 4—COMPRESSION AND EXPANSION LINES PLOTTED ON LOGARITHMIC PAPER

feeling that it is advisable to go back to the air-injection engine, not necessarily as the ultimate engine, but certainly as the model of our desires.

Returning again to the ideal expansion line, it is obvious, of course, that the true adiabatic, $n = 1.41$, cannot be obtained. Radiation to the walls and jackets will lower the slope of the line more at the top than at the toe by reason of greater loss under the high temperature at the peak. The compression line follows the same conditions and has values $n = 1.30$ to 1.35.

It would seem that the expansion line should follow the same law, and practice bears this out. A late solid-

injection engine tested by the writer did an economy of 0.446 lb. per brake horsepower-hour. It had a compression of approximately 275 lb. gage, and developed a maximum of about 500 lb. at full load. It added heat at very nearly the isothermal rate for about 22 per cent of its stroke and then continued expansion with an exponent $n = 1.327$ to exhaust. This is shown in line



FIGS. 5 AND 6—AFTERBURNING SHOWN BY EXPANSION LINES

abc on Fig. 4. It is safe to assume that afterburning ceased at *b*, and it was noticed that the point *b* was extended toward the toe under bad spray or exhaust conditions. This line approaches the ideal, and the Clayton method makes very obvious where improvement must be sought.

If the ideal expansion line should show an exponent $n = 1.30$ to $n = 1.35$, and if such a line indicates expansion truly adiabatic but modified by radiation losses to the walls and jacket, it is obvious that with values n between 1.20 and 1.3 heat has been added down the stroke or afterburning has taken place.

It is possible with the same compression and the same quantity of heat supplied to have theoretical extremes of 37 and 61 per cent efficiency, due to a difference in the value of the exponent n, both of which will be about equally reduced by jacket losses. The necessity of having as high a value of n as possible is obvious. The long climb out of the condition when the best solid-injection expansion line attainable showed an exponent $n = 1.2$ to the present state of approach to the air-injection ideal has been accomplished by better scavenging, better injection-system design and improved combustion chambers. In whatever degree these details are excellent, so also is afterburning reduced. It is hoped that this exposition and revival of Mr. Clayton's work will tempt others to investigate their designs and products with the idea of increasing the efficiency and value of the oil engine.

In co-operation with the Combustion Engineering Corporation, tests are to be conducted by the Bureau of Mines at the River Rouge plant of the Ford Motor Co. on the largest boilers so far constructed. These tests will supplement the knowledge gained in previous tests on differently designed boilers burning powdered coal.

Notes on the Generation of Steam

BY C. A. JOERGER

Emphasizes the Necessity of Differentiating Between Ideal and Commercially Efficient Practices

Because of the high price of coal, labor, equipment and everything else connected with the generation of steam, there has been a great movement for an increase in economy. Much has been written and much has been said upon the methods of obtaining this increase—in fact, so much that basic principles have often been disregarded.

That there is room for economy is unquestionably true. Taking boiler tests of the last three years that the writer has made, tests made under actual working conditions show a steam-generating efficiency of 56 per cent for boilers up to 3,000 sq.ft. heating surface and 67 per cent between 3,000 and 5,000 sq.ft. This is not particularly good. In most cases it was not difficult to improve the performance, yet, sometimes when changes were under discussion engineers would show utter lack of some of the fundamental principles. To illustrate this point a few examples will be given.

SOME EXCESS AIR NECESSARY

In a certain plant the engineer made frequent flue-gas analyses to make sure that there was above all not too much air. His hobby was excess air. It is well known that in most plants the loss due to excess air is the greatest loss, but it cannot be totally eliminated. This engineer was determined to stop all excess air, but it is practically impossible to do so, for there will always at least be the law of mass action. An appreciable time is required for combustion as explained by this law.

This law of mass action can be well illustrated by the fact that the more water used the easier it is to dissolve a certain amount of salt or sugar. Roughly, the law of mass action states that the speed of a chemical reaction is proportional to the weights of the reacting substances present in a unit volume. When, in a mixture of air and furnace gases, some of the oxygen unites with carbon monoxide, this oxygen is no longer available for oxidizing the remaining combustion. The products of combustion are then in the way and fewer oxygen and carbon-monoxide molecules are left, so that the molecules of oxygen meet the molecules of combustible gas less frequently. As the combination proceeds, the masses of free oxygen and combustible gas become less and less compared with the total mass of gas present, and their combination becomes slower until it is nearly zero. Were the air supply in the ordinary furnace limited to the theoretical amount, the reaction would take so long, assuming the present gas-mixing arrangements, that the gases would have passed through the furnace before completing combustion. Therefore, it is evident that excess air is necessary for the liberation of heat in the short time allowed in a furnace.

Practically the same problem arises from another angle; namely, high CO_2. Many engineers keep preaching to go as high in CO_2 as you can without producing unburned gases. One engineer, for example, said 15 per cent CO_2 is a good mark to shoot at. In one case where

this was done, and at the end of a week the furnace was inspected, it was found that most of the firebricks had run into "icicles." The furnace had been too hot. The damaged brickwork was replaced at considerable cost. A little more excess air would have more than paid for the loss in heat because of it. The correct CO_2 to obtain would hence be that which would net the most steam for a dollar, everything taken into consideration. It is dangerous to preach 15 per cent CO_2 when in many cases 9 or 10 per cent is the best. It is all a matter of the design and characteristics of the equipment.

Capacity, Efficiency and Economy

The terms capacity, efficiency and economy are often confused, the confusion arising in the fact that they are likely to be used independently of each other and without examining their effect on other efficiencies. For example, it is sometimes advantageous to use a low-priced coal that gives 65 per cent furnace and boiler efficiency as against a higher-priced coal that gives 75 per cent efficiency. The efficiency of the dollar is the real criterion. An increase in capacity at a sacrifice of efficiency may make for economy by saving fixed charges on additional boilers and equipment.

It is very well to know the calorific value of coals as found by the calorimeter method, but coals that show the same calorific value differ in actual commercial value as steam producers. Besides the laboratory test of the fuel it is necessary to supplement it by measurements of fuel consumed and water evaporated in the plant.

Furnace design undoubtedly influences the cost of production, but there are no fixed standards to determine definitely the proper equipment or fuel to use. Each must be selected with reference to the other and the suitability of the combination to the plant requirements and conditions. Sometimes a different type or arrangement of boilers and furnaces may decrease labor, fuel and time, utilize the floor space to better advantage, and provide more comfortable working conditions. These generally result in an increased output and lowered production cost even with the same unit prices for fuel, labor and material.

Many absurd comparisons are made between different fuels merely on their heat-unit content without regard to physical and chemical form, which very largely determine their field of usefulness. Whenever there is a difference in physical or chemical form of the fuel or in mechanical equipment, there is a difference in economic value regardless of comparative thermal value or price.

Price of fuel is but one item in the cost of steam generation just as it is but one item in the cost of transportation. Operating cost includes not only the price of fuel, but also the quantity consumed, which is largely governed by the manner of utilizing the heat. This in turn is greatly influenced by the design and method of operating the appliance, whether it be a furnace or an automobile.

It is also a common and wasteful practice to delegate to unskilled men the control of firing. There is a distinct difference between the art of firing and just burning coal. This practice must stop. It pays in dollars.

Smoke Prevention

There has been considerable agitation against smoke, and many cities have smoke-prevention departments to help and enforce smoke prevention. There are two viewpoints to the objection to smoke; one is "public nuisance" and the other "fuel loss." The first is the real ground for stopping smoke emission, and the smoke-prevention departments have effective methods along this line. But as to the "fuel loss" there is a different story. Many plants are wasting more fuel since operating smokelessly than before because of using too much excess air. It is well known that the loss due to excess air in most boilers is greater than that due to incomplete combustion.

Smoke-prevention departments are in general doing good work, but to continue doing so it must be remembered that they must have:

1. No political interference.
2. Funds to employ expert inspectors.
3. Educational methods to gain their object.
4. Co-operation of power-plant owners.

Ideal Versus Practical Recommendations

There are many articles and lectures that constantly place before operating engineers what it is possible to do in a power plant, but it is necessary that operators be not confused as to what is ideal and what is practical in operation. Often, exaggerated ideas are given to owners of power plants as to what can be done to improve the net earnings by suggestions that are ideal and not practical. Almost anyone can go into an average plant and make suggestions that will give economy in operation, but there is always the question whether the improvements will show a net gain in the long run when everything is taken into consideration, including the human element. The real task is to differentiate between improvements that apparently show a gain but do not and those that do.

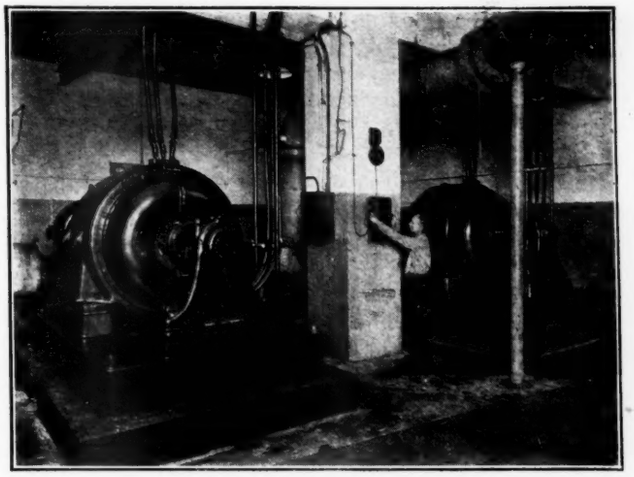
There are many other factors that can be considered in the efficient generation of steam, but the foregoing are pointed out simply to emphasize that every factor has more than one angle to it and every phase of it must be considered, and what appears as a solution in one case is not necessarily a solution in another. An open mind and a willingness to be convinced are absolutely necessary.

Low Power Factor and How It Is Corrected

Power factor is a term used to express that relationship existing between the electrical constants of an alternating-current circuit which causes the product of the volts and amperes to exceed the true power. If the circuit loads are not carefully chosen for alternating current, the power factor is liable to be low. The copper loss varies inversely as the square of the power factor, consequently if the latter is not maintained at a high value, there is likely to be an excessive waste of power in the circuits. Low power factor also causes poor regulation of the entire system, giving marked deleterious effects upon lights and motors, especially on the latter if they have to be started frequently.

Low power factor is caused most generally by induction motors that are run at a small fraction of their rated load. Poor power factor is corrected by choosing induction motors more suited to the load; by choosing another type of motor such as synchronous unity power factor motors; by installing synchronous or static condensers; or by using synchronous motors driving mechanical load and operating at a leading power factor. A synchronous condenser is merely a synchronous motor, and it is frequently most economical to make it perform the functions of both a condenser and a motor.

Pumping Station 360 Ft. Underground



SUPPLANTING an air lift system comprising ten deep wells with underground pumping station equipped with two 3,500-gal. per min. two-stage centrifugal pumps driven by slip-ring induction motors equipped with liquid control. Pumps and motors specially designed to give high efficiency over wide range of operation.

SINCE its inception in 1908 the Argo plant of the Corn Products Refining Co., which is some fifteen miles southwest of Chicago, has grown into one of the largest plants owned by the company. For the various manufacturing processes a great volume of pure water is required, the quantity consumed at the present time ranging from 3½ to 4 million gallons per day, when the plant is running full capacity. This water is obtained from ten wells from 1,500 to 1,600 ft. deep scattered about the property.

Until recently, the water was pumped by means of an air lift in each well delivering to a centrally located reservoir from which the circulating pumps drew their supply and forced the water to all parts of the plant as needed. When pumping began in 1908, the water in the wells stood about 90 ft. below the ground surface, but with the lapse of time and continuous pumping at an increasing rate, this level has been lowered somewhat, with a decrease in the efficiency of the air lift and an increase in the cost of pumping.

Two cross-compound air compressors, rated to deliver 3,500 cu.ft. of free air per minute each, supplied the air for the wells at 150 lb. pressure through an 8-in. header to which taps to the various wells were made. Depending upon conditions, the air pressure at the individual wells ranged from 86 to 125 lb.

With the air lifts operating in all ten wells, it was impossible to obtain more than 3,000,000 gal. of water per day. With the growing needs of the plant this quantity was insufficient, and as the level of the water in the wells receded, this amount of water was obtained at low efficiency, for to reach the maximum pumpage it was necessary to operate both air compressors at full capacity and to use much more air than ordinarily would have been required.

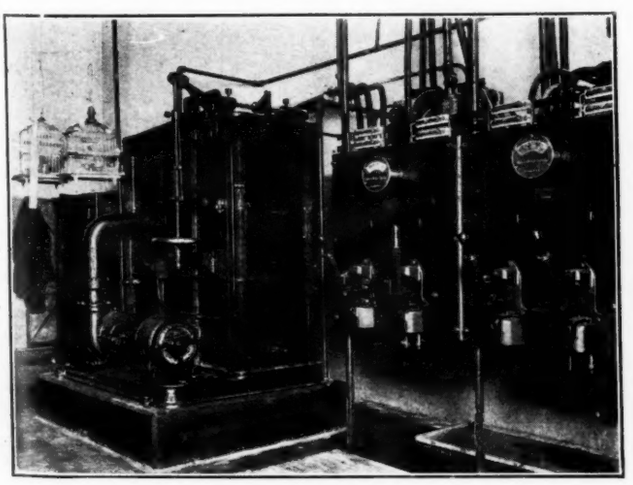


FIG. 1—LIQUID CONTROLLER AND MOTOR PANELS

To reduce the cost of pumping therefore, and to insure a supply sufficient for future requirements, were the problems to be considered by the engineering department of the Corn Products Refining Co. In the vicinity of Argo there was no other source of supply except the wells in operation. Water from the city mains of Chicago was not available and the cost of a pipe line to Lake Michigan, 12 miles away, would have been prohibitive. It was therefore decided to install an underground pumping station, motor operated, and connect the ten wells by means of an underground tunnel at a level that would always insure an abundant supply of water to the pumps.

Total Length of Connecting Tunnels 3935 Feet

That part of the work preliminary to the installation of the pumping equipment consisted of the construction of a concrete-lined vertical shaft of 13 ft. inside diameter, extending approximately 360 ft. below the surface of the ground, an enlargement at this depth to form a pumping chamber approximately 38x40 ft. in plan, with headroom of 11 ft. 6 in., and a 4x6-ft. tunnel driven horizontally from this pump chamber to a total length of 3,935 ft. A pipe line in the tunnel system with a valved connection to each well was to be laid to conduct the water to the pump chamber. The scheme included two electrically driven centrifugal pumps located in the pump chamber to take the water from the pipe line and force it up the shaft to the reservoir above ground formerly filled by the air lifts.

The general layout of the wells and the pumping station is indicated in Fig. 2. The rectangle in the upper part of the drawing indicates the position of the shaft and the pump chamber, while the circles marked No. 2, 3, etc., show the locations of the different wells and the full lines connecting these points represent the tunnels. The distance between the wells and the size of the pipe lines are also given.

It is reported that the making of the survey required great care, as the site was obstructed by a number of large buildings not shown in the drawing and many railroad tracks on which cars were standing when the survey was made. Locating wells 8 in. in diameter at a depth of 360 ft. underground was no easy task. Throughout the construction work unusual difficulties

were encountered and unique methods were employed to overcome them, but this part of the story is to be told in full detail in a paper soon to be presented to the western Society of Engineers by L. J. Hotchkiss, of the Foundation Company, who had direct supervision of the work.

In the pump chamber, which is a reinforced concrete room of the dimensions previously given, two motor-driven two-stage hydraucone centrifugal pumps making

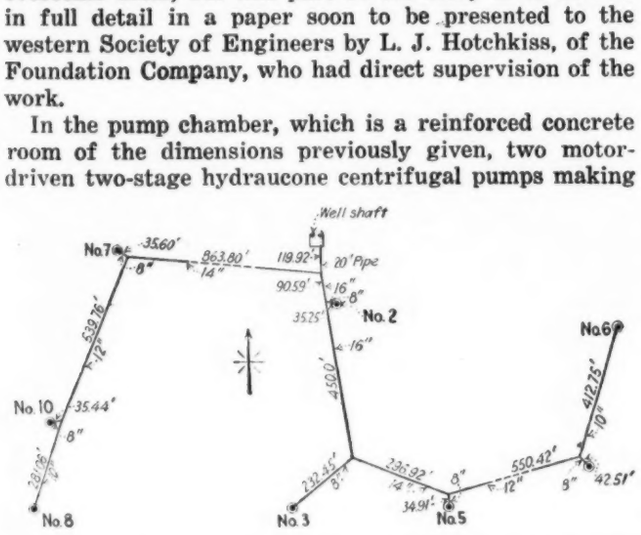


FIG. 2—GENERAL LAYOUT OF WELLS SHOWING LOCATION OF TUNNEL AND PUMPING STATION

1,480 r.p.m. and having a capacity of 3,500 gal. per min. each against a total head of 400 ft., were installed by the Allis-Chalmers Manufacturing Co. A turbine-driven sump pump to keep the room dry is provided, and an Otis passenger elevator gives access to the room from the ground level.

Hydraucone Type of Pump Used

Each of the pumps has a 12-in. discharge nozzle and a 14-in. suction nozzle extending horizontally from the lower half casing on opposite sides of the pump. It should be explained that the hydraucone type of pump is a special two-stage design having two impellers mounted back to back on the shaft and each impeller discharging into a separate volute passage. The volute passage into which the first-stage runner discharges flares out and there is a plate fastened close to this nozzle so as to form a hydraucone diffuser which converts the velocity of the water leaving the first-stage impeller, into pressure with a minimum hydraulic loss before it flows around to the suction of the second-stage impeller. Such a pump is efficient without the use of diffusion vanes and has a high efficiency over a considerable capacity range. Also the opposed arrangement of the runners gives a balanced construction under ordinary pumping conditions, so that there should be little axial thrust, and what there is can be carried by a ball thrust bearing provided at the end of the outboard pump bearing.

Under the rated conditions an efficiency guarantee of 74 per cent for the pump was given, and in shop tests this efficiency was exceeded. Tests on the pump showed further that the efficiency was above 70 per cent from 66 per cent of rated capacity to 111 per cent, and that the pressure rise from the rated head to shutoff pressure was only 18 per cent.

Each pump is connected directly to a 525-hp. three-phase 550-volt slip-ring type induction motor making 1,480 r.p.m. The machines are started as slip-ring motors to minimize the sudden pull of current from the generating station, but when up to speed and pulling a load, they are operated as ordinary induction motors. Starters of the liquid control type are employed.

The motors are of the two-pole type cooled by means of air drawn in at each end of the motor and forced out through the feet into the base pit. With the exception of this ventilating feature they are totally inclosed to exclude any falling moisture or prevent the settling of dust or dirt in the machine proper. The machines rest in pedestal bearings and have a short-circuiting and brush-lifting device operated by a hand lever on the slip-ring end of the motor, this device being interlocked with a magnetic lock on the primary oil switch. Being of the two-pole high-speed type, the motors are efficient. At full load they are credited with an efficiency of 93.5 per cent and have the high operating power factor of 94.5 per cent.

Liquid Controller Employed for Starting and Slow-Speed Operation

As a liquid controller on a pumping unit is somewhat unusual, it may be of interest to state that the control consists of a cast-iron tank divided horizontally into two compartments—an upper compartment containing the electrodes and a lower compartment containing the electrolyte and cooling coil. A small motor-driven centrifugal pump at the side of the controller transfers the electrolyte from the lower to the upper compartment, and while the control is in operation this pump operates continuously. A multi-shutter weir is located at one end of the upper compartment. This weir is operated by a hand-wheel located at the side of the controller tank. One controller is used for starting both pumps.

Switches with interlocks are provided so that only the one set of switches for one motor can be operated at a time and are farther interlocked so that when one motor is being started the weirs must be wide open and the brushes must be on the rings of the motor and the rotor

FIG. 3—SECTION OF TUNNEL

short-circuiting switch open. Under these conditions the operator in starting a motor closes a switch which connects the controller electrodes to the slip-rings of the motor to be started. He then starts the small electrolyte pump, after which he closes the primary oil switch to the main motor. This starts the motor with full rotor resistance. The motor is brought to full speed by turning the handwheel, gradually closing the weirs. This causes the electrolyte to rise in the electrode chamber and by gradually submerging the electrodes cuts out

resistance. Such a method gives uniform acceleration as the resistance is cut out through an infinite number of steps. When the electrodes are fully submerged, the excess electrolyte flows over the top of the weirs to the bottom compartment. At this stage the motor is at full speed and the secondary resistance is all cut out, so that the short-circuiting switch can be closed and the brushes raised. The controller weirs can then be opened and the controller disconnected from the motor and utilized for starting the other motor.

With this type of control it is possible to operate a pump at any desired reduced speeds within the limits of the design of the controller and obtain reduced pumping capacity. The liquid controller also has the advantage of not having any moving or arcing contacts. The outfit is safe, occupies comparatively little space and there is no danger of burning out resistance when running for long periods at reduced speeds.

A passenger elevator has been installed in the shaft having a capacity of 500 lb. and a speed of 125 ft. per min. A speed governor under the car automatically throws into service safety dogs which grip the steel guides. An additional safety precaution is a safety brake on the driving machinery, which automatically grips when the car is brought to a stop or when the current is shut off. This brake is released by throwing on the current. On both car and counterweight there are stopping switches at the top and at the bottom of the shaft.

The caged canaries shown in Fig. 1 were not selected for their singing qualities nor for the entertainment of the plant operator, but rather for his safety, as the birds are particularly sensitive to the presence of gas, their demise indicating its presence before it could in any way prove harmful to the operator of the pumping station.

No figures are available as to the cost of pumping, but capacities exceeding 4,000,000 gal. per day have been obtained, and a sufficient supply of water for any anticipated future demand is available.

Compressor Faults Revealed by the Indicator

By R. McLAREN

HUNDREDS of compressors are in constant operation having a high power consumption and low volumetric efficiency simply because no one has taken the trouble to investigate the machines as operated. The indicating of air compressors is an interesting work, and the decrease in power consumption after correcting the defects so shown amply repays the engineer for the trouble.

An example of faulty operation is shown by the full-line diagram in Fig. 1. This indicator diagram was

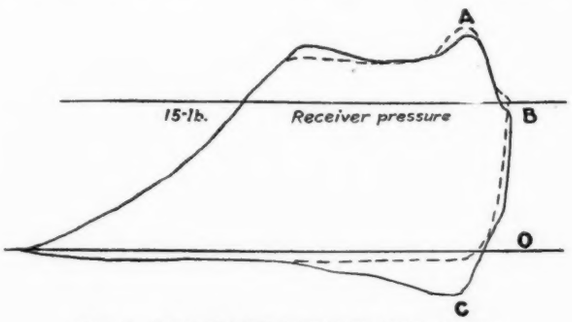


FIG. 1—DIAGRAMS BEFORE AND AFTER VALVES WERE RESET

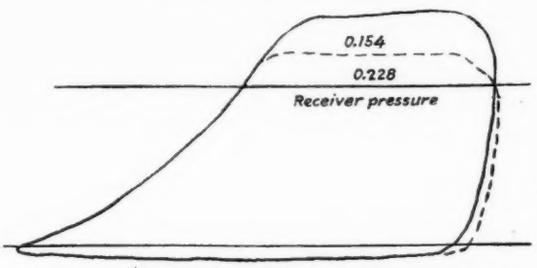


FIG. 2—LIGHT AND HEAVY VALVE SPRINGS GAVE THESE DIAGRAMS

taken from a 20x16-in. motor-driven compressor having inlet valves of the oscillating Corliss single-ported type. The discharge valves were of the spring-loaded poppet or mushroom type.

All who are familiar with air compressors will agree that the diagram reveals most unsatisfactory conditions, as to both the suction and discharge lines. In an endeavor to eliminate the objectionable drop in the suction line, I reset the Corliss valves but without satisfactory results, although I followed the builder's instructions as to adjustment of the eccentric handling the valves. It was impossible to alter the position of the valves on

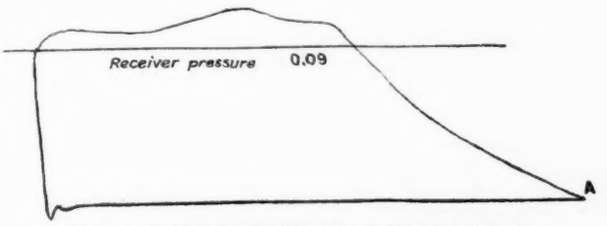


FIG. 3—TOE OF DIAGRAM CAUSED BY AIR COLUMN INERTIA

FIG. 4—DIAGRAM TAKEN AFTER SUCTION PIPE WAS REMOVED

the spindles to bring the valves to their correct positions without the use of offset keys or new keying. Offset keys were used, being the easier of the two methods. This readjustment resulted in the cylinder's giving the diagram shown in broken lines in Fig. 1. In this case 17 per cent of the diagram area lies above the receiver pressure line, while in the full-line diagram taken before adjustment the amount was 19 per cent. The suction line was straightened out by the change even though the discharge line was still objectionable.

New type discharge valves were obtained from the builders, but the springs seemed absurdly stiff. The installation of these valves gave the full-line diagram in

Fig. 2, where the percentage of area above the receiver pressure line has risen to almost 23 per cent. A new set of lighter valves were put on the compressor, the dotted line diagram in Fig. 2 resulting. The area above receiver pressure line here has dropped to 15.4 per cent.

This compressor is equipped with a suction unloader which operates by shutting off the air supply to the compressor entirely. It is quite probable that the difference between the suction lines of the several diagrams shown

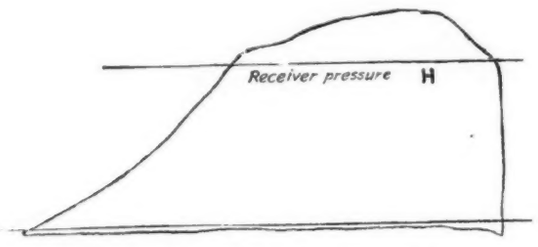


FIG. 5—DIAGRAM AT SLOW SPEED

is due to interference of the unloader which, when the diagrams in Fig. 2 were taken, may not have been fully open.

Fig. 3 is from a 36x36-in. steam-driven compressor with inlet valves of the Brown or multi-ported grid type and discharge valves of the automatic spring-loaded type. The opening and the closing of the inlet valves are independent of each other, the usual Brown cam effecting the opening and a separate eccentric the closing. The unloader operates by holding the valve open and permitting the air to surge in and out of the cylinder. It will be noticed that there is a slight loss at the beginning of compression at point *A*. This is due to the inlet valve's being a loose fit in the guide, permitting it to fall back from its seat slightly, the outflow of of air bringing it up to its seat and stopping the leak. The remedy was to make the valve stem a good fit.

After disconnecting the intake pipe, Fig. 4 was taken. It will be noticed that there is a difference at the heel of the diagram. In Fig. 3 the sharp drop in the suction line at the moment of suction valve opening was undoubtedly due to inertia in the column of air in the suction pipe, which was about 25 ft. long. When the pipe is removed, there is no inertia to overcome, therefore there is no drop in the diagram in Fig. 4.

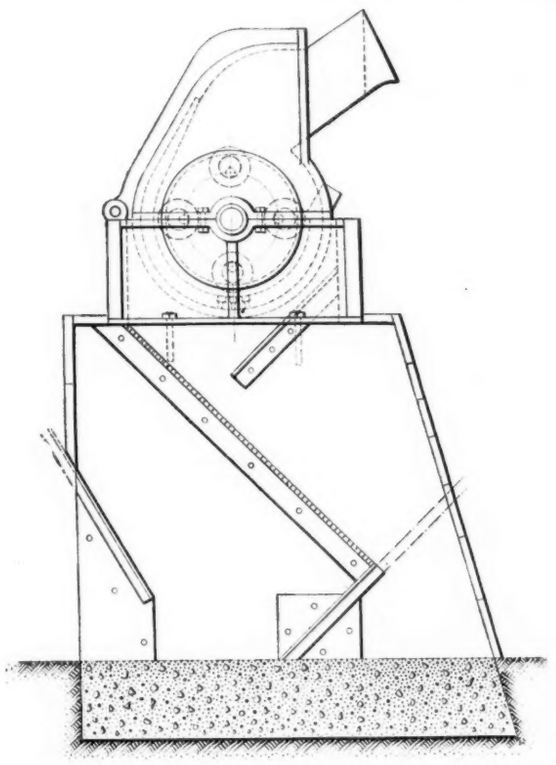
It is obvious that the longer the suction line the greater will be the force required to overcome the inertia of the columns and therefore the greater the drop at the heel of the diagram. Compressor speed also influences the diagram shape. Fig. 5, which is from the same compressor from which Fig. 3 was obtained but now running at 60 r.p.m., proves this. This diagram is shorter than the others owing to the use of a smaller stroke reducing-wheel bushing.

Pulverizing Firebrick To Line Furnace Walls

In the power plant the utilization of used firebrick for the making up of plastic material to face the furnace walls is becoming common practice. The damaged and broken brick are crushed to a fairly uniform size and mixed with high-temperature cement to form a stiff mass, plastic enough to be workable. Owing to the extra burning it has received in the boiler furnace, this material is reported to resist high temperatures better than the original refractory.

For grinding this brick, the American Pulverizer Co., St. Louis, Mo., is now supplying a ring pulverizer such as is used by brick manufacturers to grind broken brick into grog for the shortening of clay or in glass factories for the grinding of glass cullets. The particular machine selected has a capacity of one ton per hour. It is driven at 600 r.p.m. by a 10-hp. motor. The pulverizer has four arms with the rolls pivoted on 1-in. pins so as to give a flexibility of 1½ in. in order that the rolls may pass over hard foreign material with impunity. Actuated by centrifugal force, the rolls crush and press the brick through patent grate bars with ⅛-in. openings, which may be increased to ¼ in. by reversing the spacing bars.

As indicated in the illustration, the pulverizer is mounted on a raised platform. The crushed brick from the machine is deflected by a baffle over an inclined



SHOWING MOUNTING OF RING PULVERIZER FOR CRUSHING FIREBRICK

screen, so that the fine material falls through into one compartment and the coarser particles roll down into a second compartment. In making up the cement, it is then possible to use the desired proportions of fine and coarse material.

The troubles that may develop in the primary winding of an induction motor are short-circuits, open circuits or grounds. Short-circuits may occur between turns in a coil, between coils in one phase or between phases. Short-circuits between coils or phases are usually quite severe and their location easily found. They must be repaired before operation can be resumed. A short-circuit between turns in a coil might not cut out sufficient turns to affect the operation of the motor. It will, however, create a local short-circuit in the defective coil and cause heating of this particular coil.

EDITORIALS

F. R. LOW, EDITOR

A New High-Pressure Development

ALMOST every day there is some new evidence that engineering leaders both here and abroad are thinking seriously about higher steam pressures. Our present steam data, inadequate as they are in the higher ranges, clearly show that substantial thermal savings are possible. A few of the more adventurous spirits are going out after these savings, and with fair prospects of commercial success. Their first problem is, of course, that of producing and using high-pressure steam not only with thermal economy, but also with reasonable reliability and safety. Their second problem—but one equally important if high pressures (that is, pressures of 1,000 lb. or more) are to come into general use—is to build such plants without counterbalancing the thermal gains by increased operating and investment costs.

Most of the mechanical problems involved in the production and use of high-pressure steam have already been solved after a fashion. Their more perfect solution seems only a matter of time. High temperatures, which must exist if the high-pressure steam is to be superheated to any marked degree, introduce more difficult problems. Yet even these—with the help of skilled designers and metallurgists—give promise of satisfactory solution. It is still too early to tell what such plants will cost as compared with ordinary plants. Evidently, more expensive materials will be required, but it seems probable that the smaller amount needed will largely compensate for this. The cost, as well as reliability and safety, must depend to a large extent on the particular design and type of construction.

An article on page 238 of this issue tells of a Swedish boiler that has been operating for more than a year at 900 lb. pressure and is designed to carry 1,500 lb. As far as can be learned, operation has been successful. Much credit must be given to the inventor for his courage in breaking away from all tradition even to the extent of rotating the tubes. No one should blame American engineers, however, if they are at first a little skeptical as to the safety and reliability of the arrangement used. They will naturally wonder what would happen if the driving motor should stop, thus allowing the centrifugal shell of water to fall to the bottom of the "rotor." Another question will be as to the extent of the disaster if a rotor should explode. In this connection it should be noted that the rotor of ten-and-one-half-inch internal diameter with a one-and-one-half-inch thick shell of water contains about four times the volume of water (per foot of length) carried by an ordinary four-inch boiler tube. Again, the apparatus required for reading the water level will seem to lack the extreme simplicity that characterizes the ordinary water column and gage glass.

All these things must be considered, but they should not lead to hasty conclusions with regard to this particular boiler or high pressures in general. The wise ones will keep in mind the builders of wooden ships, who laughed at the idea that ships would ever be made of iron. They may hang onto their own money while the other fellows do the experimenting, but they will not fail to keep informed on every new development in this field.

Cost of Over-Development in the Coal Industry

THE Federal Coal Commission concludes, on the basis of unquestionable data, that there are approximately two hundred thousand more coal miners in the United States than are needed, even for the most active and effective operation of the coal industry. The Commission also emphasizes in its recent report the over-investment in the business which now provides for a capacity largely in excess of eight hundred million tons a year, whereas the maximum that the country has ever been able to absorb and export is much less than six hundred million tons. The coal user is vitally concerned in knowing what this over-development means to him and more still in knowing how the situation may be corrected.

If one assumes that these two hundred thousand extra miners get on the average of fifteen hundred dollars a year, which is approximately the rate estimated for all miners in the United States by the Bureau of Labor Statistics, the burden on the coal user from this cause would be three hundred million dollars a year in unnecessary wages. The extra investment in the business must amount to something like five hundred million dollars on which insurance, taxes, interest, depreciation and profit are undoubtedly expected by the owners. Probably twenty per cent a year would not be an unreasonable estimate of the extent of these charges on this capital. This percentage would amount to approximately one hundred million dollars per year of expense for needless capital.

The total of wages and interest burden of the coal user thus can be computed to be four hundred million dollars, or approximately seventy-five cents per ton for all of the coal used in the United States. Of course it is idle to assume that all this could be saved, for some of the earnings of surplus miners would have to go to pay for the work of useful employees were their work increased to the point that we could get rid of all of the needless workers. Also some of the surplus investment doubtless will shortly become productive or may be necessary in order to furnish a balance wheel on prices for coal. Nevertheless, a good portion of the seventy-five cents per ton is waste, profitable neither to mine workers, mine owner nor coal user.

One very constructive suggestion for reduction of the number of surplus mine workers is that other branches of industry shall look about in the coal-mine regions to recruit forces that are now being built up for increased capacity operation of industry. Certainly, those

industries that are complaining regarding shortage of workers should do this. It will be much more to the point for industry to hire a few miners and teach them other skilled or unskilled trades than for these industries to complain regarding the effect of the immigration restrictions which are claimed to result in labor shortage.

Anything that will relieve the coal industry of part of its burden of surplus labor and surplus investment is worth while. It will benefit the coal industry to some slight extent, but it will benefit to a considerable extent the users of coal.

Cost Versus Availability

ALTHOUGH power has become one of the most important factors in human existence, it is by no means one of the big items in the cost of living; in fact, it is one of the smallest. There are certain industrial processes that require large blocks of cheap power to make them commercially possible, but these are the exception and not the rule. In the average industry power is not a relatively big item in the total expense of production, even though the increased cost of fuel, labor and equipment has, during the last five years, increased this factor considerably. In the home the average power bill for lighting and for operating household devices is by no means a heavy burden. Of course the public should not have to pay any more than a just compensation for an adequate service, but there is another factor that, in a certain sense, is of vastly more importance than the cost of power, and that is the availability of the supply. During the war it was not the cost of power that caused the country inconvenience, but the shortage in the supply.

Not infrequently, the importance of the availability of an adequate power supply is confused with the cost for the service and made to look as though cheapness of the supply was the predominating feature. To attain this goal of cheap power for everybody, attention is directed to water-power development. Governor Smith of New York recently said, "I would develop the water power of the state so that electric power could be furnished to the cobbler at his bench and the washerwoman in her kitchen at the cheapest possible price." One of the misleading parts of this statement is the inference that the present cost of power is keeping it outside the reach of the cobbler and washerwoman, when the most serious obstacle in the way is the cost of the devices with which to utilize the power.

As far as developing the water powers of the state is concerned, a very large percentage of the total power is on the boundary between New York State and Canada and requires a treaty between this country and Canada, something over which the Governor has no control. Even after the international political entanglements have been cleared away, the development of the St. Lawrence as a source of cheap power is a doubtful undertaking except in conjunction with a canalization of the river, a project New York State opposes. Of the water power of the state not on the international boundary, a large percentage is already in use, so that development of the remainder is not going to affect the general power situation very materially.

In the layman's mind there is an idea that water power does not cost anything. Neither does coal cost anything so long as it is allowed to remain in the ground. Coal, to be available for power purposes, must be mined and transported to a power plant. Before water can be utilized for power, various kinds of control work must be constructed, including dams, tunnels, canals, penstocks, etc., all of which may make the water expensive by the time it reaches the plant. In fact, the cost of developing many water-power sites precludes their competing with fuel-burning plants at the present time. The Federal water-power policy is not to obtain the lowest power cost in utilizing our water powers, but to obtain the greatest amount of power from a given site consistent with a reasonable cost. This is also true of the Canadian government regarding the water powers of that country. Such a policy is a commendable and intelligent one, even though it does not result in producing power at the lowest cost. Our water powers are limited, and any policy of development that does not make the best use of these resources can result in nothing but an economical blunder. Hydro-electric equipment has been developed to about as high efficiency as ever can be expected, and once a mistake is made in a water-power development it cannot be economically corrected by installing more efficient and improved machinery, as may be done in a steam plant.

A Chief Engineer's Qualifications

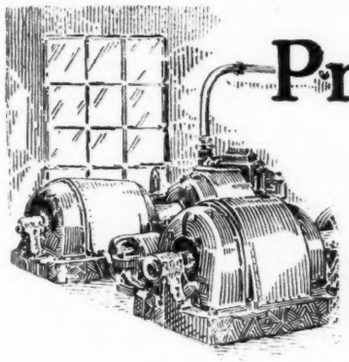
WHEN visiting power plants one finds chief engineers of many characteristics and qualifications who might be classed as real and would-be engineers and very often a short survey of a plant and operating staff will reveal in which group the chief belongs, as his ability and influence are often reflected in the personnel and morale of his staff.

One of the fundamentals of success in a chief engineer is his ability to size up men and select those best suited to the various duties in the plant, those who will put their best efforts into their work. If he can do this, nine-tenths of his troubles will disappear.

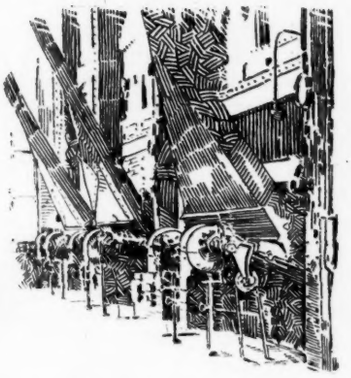
Care in selecting employees is of paramount importance in the building up of an efficient staff. Many engineers, however, are handicapped in this respect by some established custom of hiring help. In different establishments the methods of selecting employees vary widely, but no matter what routine is followed, in justice to the chief he should be allowed to pass upon the applicant and not have anyone forced upon him without his approval, as is often the case.

The man in responsible charge of a modern plant must possess qualifications that involve as much mental capacity, study, practical and intelligent application as many other professions. He must have an intimate knowledge of the system and equipment he controls and be able to direct the work in any branch, although it is not necessary that he be able to execute the work himself to a fine degree, as so many engineers believe. Assistants are usually available who specialize in some one line, and this type should be selected and given the responsibility of the work in the different departments.

Many young engineers who aspire to a chief's position are imbued with the idea that a varied experience is the one and only requisite, but while experience with different types of equipment is always valuable, it is by no means the only requirement. The aspirant should endeavor to acquire at the same time some executive ability and should study the different ways of handling men to obtain the best results, for in the final analysis it is the ability to organize and build up an efficient staff that counts fully as much as a high degree of technical training and mechanical skill.



Practical Ideas *from* Practical Men



Scraping Oil-Engine Bearings

While the bearings of a large Diesel should undoubtedly be scraped to a fit on the journals, this practice is not always advisable on small semi-Diesel units unless the job be done by an expert.

An experience I had with a 25-hp. semi-Diesel engine indicates that another method is far better. The crankpin received oil from a channel-ring on the side of the crank-cheek. The crankpin heated repeatedly, each time causing a total shutdown and a rescraping and fitting of the bronze crankpin liners. Finally, the heat due to the crankpin was conducted along the shaft and burned out one main bearing. Help was called for from the agent for the engine builder, who ran a machine shop some sixty miles away. He found the oil channel ring had broken, allowing all the oil fed to waste into the crankcase instead of entering the passage to the crankpin. The ring was replaced by a new one, and the main bearing was taken to a machine shop and rebabbitted on a mandrel and finished by being scraped to a fit. This proved to be poor judgment. The bearing was not quite true, and the resulting lack of alignment of the crankpin caused the other main bearing to burn out. Both main bearing shells were taken to another shop, where they were babbitted, mounted in a specially made chuck, or jig, and bored on a lathe to close caliper measurements. This, while expensive and slow, was exact, and the engine thereafter ran well. The various rebabbittings later necessary were always done the same way and proved satisfactory. Hand fitting of the bearings by scraping was never attempted.

COLIN K. LEE.

Bowling Green, Mo.

Quantity and Admission of Over-Fire Air an Important Question

I read quite recently in a trade paper a typical article on the subject of reducing waste in the boiler room. As usual, quite a little space is devoted to the subject of air infiltration, and it does not differentiate between the wasteful leakage and the introduction, at the proper place, of air over the fire to complete combustion. There is no doubt that more or less air over the fire is necessary to obtain the best results in most cases, and it is also necessary in many cases to prevent smoke. These are facts that are accepted by experienced engineers but are not understood by many. The error mentioned, which is really an incomplete rather than an incorrect statement, frequently makes it difficult, if not impossible, for a combustion engineer to correct operation or design in a plant.

The strongest opposition usually comes from the manager or owner who is a non-technical man. He has at various times read some such misleading articles as the one referred to, and as a result he concludes that the engineer has been wrongly informed. It is true that occasional articles are written and published on the subject of over-fire air, but they do not reach the non-technical man, as a rule. Either the title or the opening remarks indicate to him that it is a technical discussion, so he does not attempt to read it.

I had an experience recently which is a good illustration of this difficulty. A plant that burned wood shavings exclusively, was having trouble with plugging up of the screen on top of the stack and was not getting full rating out of the boiler. The boiler had a large combustion chamber and a Dutch-oven furnace. The shavings and sawdust were kiln-dried and were spouted into the furnace through a hole in the top of the flat arch.

An inspection showed up the trouble at once. The furnace was choked up. So much of the fuel was run into the furnace that the grate was covered too deeply to allow enough air to pass through it, and with the furnace doors closed, only a little air got in that way. The result was a cloud of soot and unburned particles of wood. The latter were picked up by the rapid velocity of the air through the grate at a few points and carried through the boiler and up the stack. This was a horizontal return-tubular boiler and the tubes became badly sooted in a short time, which further aggravated the trouble by reducing the furnace draft.

It was surprising how quickly the fire picked up and the stack cleared after the furnace doors were opened. In a short time the furnace brickwork was hot, the combustion chamber was clear of smoke, and the boiler was running at over rating. Once the fire was going nicely, it was comparatively easy to regulate the air over the fire by varying the opening of the furnace doors to meet the requirements as indicated by the appearance of the fire or by watching the stack.

The results were there, but the superintendent of the plant was far from convinced. He could not see how cold air rushing in the furnace doors was not bad for the boiler. As a matter of fact this cold air never got past the furnace as the fire was made hotter, and as a result only hotter gases reached the boiler. No doubt, there will be times at this plant when more harm than good will be done, but only on account of incompetent regulation of this over-fire air. Also, all the ills of this boiler will be blamed on this practice, no matter how little connection there may be, but the theory is right and will always get results if properly applied. It is an old saying that a theory is good, but

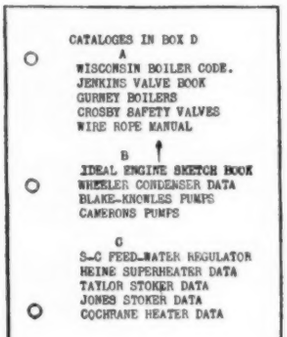
does not work in practice. A theory is always good if all details are complete, and under the latter conditions it must work.

It seems to me that writers of advice on the subject of losses due to air leakage, excess air, etc., should be more careful so as not to give wrong impressions that may lead to more harm than good in many cases.

Chicago, Ill. LOREN L. HEBBERD

System in Caring for Catalogs

It is quite the usual practice for power plant engineers to collect countless catalogs and bulletins on the different types of equipment, and after giving them the once over, to lay them aside carelessly instead of having them properly filed for future reference. Some time ago I called at a plant to make an inspection of a large engine. This engine was equipped with an automatic stop, and as I had never seen one of that particular make, I asked the engineer if he had an instruction book on this device. He replied that he did have one, but did not know just where it was, and I soon found out that he was in no way interested in the device, and knew absolutely nothing about it. To me this made the risk a poor one, as the care an engine gets is of great consideration in insurance. In talking further with me the engineer said that he had found it practically impossible to keep track of catalogs, so I outlined for him a system I have used for several years with good results.



LIST OF CATALOGS IN EACH COMPARTMENT

I first had some boxes of convenient size made of light wood, and divided into five compartments by tin slides, and in the compartments, which are numbered A, B, etc., I filed my catalogs. I then made up a list of what was in each division and pasted it on the front side of the box over the compartment. I also keep a book on my desk in which I have a duplicate list (as shown in the cut) of what is in each compartment. With this system I have a record of each catalog on hand and can readily find any one desired.

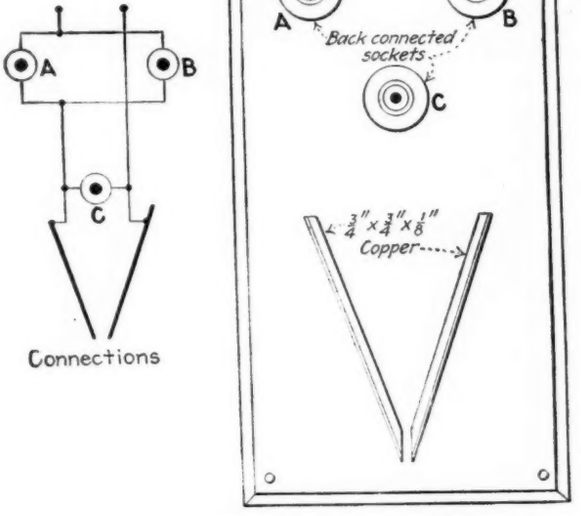
Everett, Mass. ARTHUR D. PALMER.

Hints on Maintaining Service

In generating and substations it is particularly important that certain circuits be constantly energized, which means that wiring defects, such as grounds, short-circuits, and open circuits, be remedied without delay. Frequently, the blowing of a fuse results from a momentary overload or short-circuit and conditions become normal when the fuse opens, where it is essential that defective fuses be replaced without delay. In one generating station the ampere rating of each fuse is painted near it, thereby facilitating the selection of the proper fuse. It will generally be found that satisfactory circuit protection will be afforded by a comparatively small number of different types and ratings of fuses, and spare fuses should be placed in suitable holders at points convenient to the switchboards or apparatus on which they are used. High-voltage fuses, such as those used to protect instrument potential transformers, are generally replaced by means of insulated tongs, and this device should be kept near the spare fuses. Test lamps should be instantly available for testing for potential on low-voltage circuits. Before a fuse is considered as a spare it should be tested, and the test board shown in the figure will enable fuses of both the cartridge and plug types to be rapidly tested. If the circuit through the fuse is intact, inserting it in socket *C* if of the plug type, or placing it across the copper angles if of the cartridge type, will cause the lamps in sockets *A* and *B* to light.

Ground lamps or some other form of ground detector should be connected to station service and control buses, and it is advisable to connect pilot lamps to some circuits, such as those supplying energy for the operation of relays. Such ground lamps and pilot lamps should be protected by adequate fuses. Considering circuits connected to the excitation system, the duty imposed on fuses is likely to be severe, because of the high voltage that may appear if a field winding becomes open circuited.

It is especially important that relay and control circuits be kept energized, for the trouble arising from the failure of a relay or switch to function is apt to be serious and far reaching in its effect. In some cases it is advisable to install relays that will sound an alarm in event of the failure of the current or voltage in important circuits.



ELECTRICAL CONNECTIONS AND FRONT VIEW OF TESTING BOARD

In connection with specially designed relays used to protect feeders at the Hell Gate Station, where careful attention has been given to circuit supervision, the extinguishing of a pilot lamp indicates trouble in the direct-current circuit to its corresponding relay. Each relay consists of three induction-type overload relays assembled in one case, with an ammeter forming a part of each element, hence the operator has always before him a visual indication of the alternating-current in each relay element, as well as the direct-current tripping circuit of each polyphase relay on the switchboard. RALPH BROWN.

Belden, Calif.

Comments from Readers

Hints on Being Chief Engineer

In an article entitled "Hints on Being Chief Engineer," by G. A. Briston, in the Jan. 2 issue, he uses the expression "an expert chief engineer." I would like to ask, What is an expert chief engineer? I have worked under a number of chiefs, have been one myself for several years and have never yet encountered one that I would consider an expert.

When I first started in engineering, I looked on the chief as a sort of demigod, one who must know all things pertaining to engineering. Imagine my awakening when I found that he was only human and made nearly as many mistakes as myself. I have learned since that a chief must study his job continuously in order to keep it in good shape to get the best out of it. A chief engineer should have a good working knowledge of all the operations that take place in a power house and it is well to have experience in several plants; but it is manifestly impossible for any one man to learn or hold all the information necessary to the operation of a modern power house, so that the successful chief of today must be a man who knows how to pick the men who have and can apply the knowledge required in the different power-plant departments.

One of the most successful chiefs I have ever known cannot tighten a crankpin bearing properly or even set a valve successfully, but he is a genius at hiring and placing men who can, and his department has an enviable record for satisfactory operation and economy. I know other chiefs with technical training and mechanical skill who fail to obtain the teamwork among their assistants necessary to insure good operation, so it would seem that engineering ability is really of secondary value in a chief engineer if he has the executive ability. Of course the ideal is a combination of these two requirements.

ALLAN A. BLANCHARD.

Erie, Pa.

Some Important Factors Neglected

In the Jan. 16 issue Mr. Weightman takes issue with me with regard to placing baffles in such a way as to obtain nearly a uniform velocity of the gases of combustion in their passage through water-tube boilers.

It is true that higher gas velocities will cause more heat to be imported to the water per unit of heating-surface area. Is it right, however, to criticize uniform velocity in general on such a premise? Boiler baffling strives to take the most possible out of the gases. If the gas travel in a water-tube boiler be increased in the last pass, it will be decreased in other passes unless an additional baffle be used. Any portion taken out of one pass must be added to another.

The rear pass of a water-tube boiler is least important. There the smallest amount of work is done. I agree with Mr. Weightman that last passes are often made wider than they need to be, thus cutting down the velocity here too much and really robbing the other passes of heating surface that could be more effectively used. To get a uniform velocity, first passes, as often found, should be greatly increased in size, particularly at the bottom. Also, many of the last passes found in practice should be cut down in their free area.

I still maintain that tight poured baffles give higher efficiencies than the commercial baffles put in by other methods. The reason for this is that clearances between the tubes and the baffles are usually much greater than the $\frac{1}{4}$ in. which Mr. Weightman mentioned. A clearance of $\frac{3}{4}$ in. on one side of a tube is not out of the ordinary, and the way that cast iron burns away and tile breaks and falls out, often enlarges the gas losses direct through the baffles. This can be demonstrated easily if one will take the pains to look through dust doors back of front baffles. Furthermore, how would Mr. Weightman explain increased efficiency shown by tests made on the same boilers, first with leaky baffles and then with tight poured baffles?

G. W. BLAKELEY, Consulting Engineer,
Boston, Mass. Johns-Manville, Inc.

Horsepower per Ton of Refrigeration

In *Power*, Jan. 23, John Cassiday discussed a chart which P. Wilson Evans presented in an article appearing in the issue of Jan. 2, entitled "Comparative Ammonia Condenser Reports Point Out Inefficiencies."

Useful graphical charts may be based on generally accepted formulas and be mathematically correct to solve the formulas, or may be based on well-defined experimental data such as steam properties, or may be based on the long experience of some well-known company or individual. Therefore, Mr. Cassiday's statement that "the curves are entirely erroneous" seemed surprising, as apparently one might be justified in accepting them as based on good experience.

Checking to find a possible discrepancy, the error appears in Mr. Cassiday's work. Using the ammonia chart he referred to, I worked through independently, assuming his suction and discharge pressures, and checked the result of the chart exactly. His quantities are substantially the same until he comes to the last part of his computation. $\frac{74}{42.42} = 1.74 +$ and not 1.4 as he states. This is a close check with the chart value.

Although this overcomes Mr. Cassiday's specific objection, the accuracy for this one point only of the chart is checked. After carrying through similar computations, using Professor Goodenough's tables, for four other widely separated points in the chart, it is apparent that the chart may be used for the solution of problems of this type with safety.

A further mistake in Mr. Cassiday's discussion is the statement, "In compressing this vapor, heat is added." His computations were based on the assumption of constant entropy or adiabatic compression. With adiabatic compression no heat save that of the work of

compression could be added to or abstracted from the ammonia during the compression.

A possible suggestion one could make in connection with the chart is that more information could be advantageously placed on the face of the chart. For example, in order that one in a hurry should not use this chart for a problem involving "wet compression," why not state on the chart that it is true for dry saturated suction gas only? This is mentioned in the article, but could be duplicated on the chart, as oftentimes the chart would be used without referring to specific parts of the article.

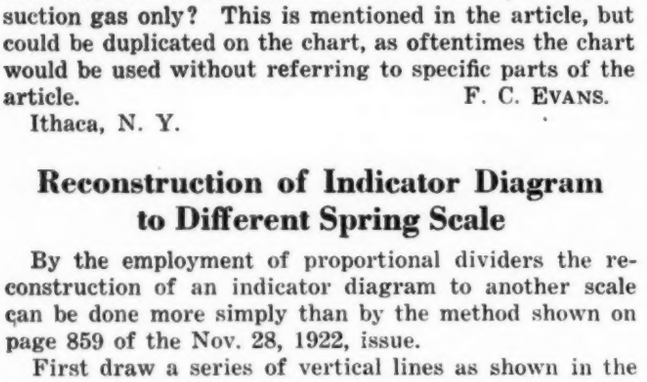
F. C. EVANS.

Ithaca, N. Y.

Reconstruction of Indicator Diagram to Different Spring Scale

By the employment of proportional dividers the reconstruction of an indicator diagram to another scale can be done more simply than by the method shown on page 859 of the Nov. 28, 1922, issue.

First draw a series of vertical lines as shown in the cut and set the dividers to the proper ratio between the



RECONSTRUCTION OF DIAGRAM BY USE OF PROPORTIONAL DIVIDERS

two scales desired, in this case 3 to 4. Then by setting the long end of the dividers to the length of the line *AC*, the short end of the dividers will give the distance *AB*. The balance of the curve can be laid off in a similar manner.

ROBERT GRIMSHAW.

New York City.

Reducing Boiler Pressure Quickly in Emergencies

I have been interested in the articles in the issues of Nov. 14, Nov. 28 and Dec. 26, 1922, on the subject of reducing boiler pressures quickly in emergencies, also in the report of tests on safety valves carried out by the A. S. M. E., given in the Dec. 12, 1922, issue.

It may be of interest to consider just how any sudden generation of steam could be caused by the opening of a safety valve. As the water in a boiler has a temperature corresponding to the pressure, the higher the pressure the greater the heat contained in the water. Sudden reduction of pressure makes available some of this heat for the conversion of a portion of the water into steam. How much this will be is of interest in this discussion.

Take, for example, a boiler carrying a pressure of 150 lb. gage. By reference to steam tables, we find that the heat in the water above 32 deg. F. is, in this case, 338 B.t.u. Then suppose, to take an extreme case, that the pressure is quickly reduced to that of the atmosphere, as in a boiler explosion. The heat above 32 deg. F. in the water will then be 180 B.t.u., rendering available 338 — 180 = 158 B.t.u. in each pound of water for the evaporation of a part of it. As it requires 970.4 B.t.u. to evaporate one pound of water "from and at" 212 deg. F., 158 B.t.u. will evaporate 158 ÷ 970.4 = 0.16 lb., or 16 per cent of the water will be converted into steam by the reduction of pressure. For other pressures the amount would of course be different.

For such a slight sudden reduction of pressure as the opening of a safety valve could cause, the evaporation due to it must be practically negligible. To take the same boiler pressure again and assume an instantaneous drop in pressure of 10 lb. when the safety valve opens, there would be only one-half of one per cent, approximately, of the weight of water converted into steam.

This plainly indicates that the drop in pressure has to be considerable for the resulting evaporation to be of any practical importance, and the tests referred to failed to detect any sudden variation in pressure at all.

Even with an appreciable sudden drop in pressure from whatever cause, the theory that the sudden evaporation of a large quantity of water can build up a dangerous pressure does not seem reasonable to me. The generation of steam, in this case, is due to a drop in pressure, and would not the effect be reversible? Would not any tendency to build up a pressure above that corresponding to its temperature result in condensation which would counteract such a tendency?

The real danger from a sudden excessive release of steam from a boiler is water-hammer, caused by large quantities of water being carried along with the large amount of steam rising through it.

I would not consider it dangerous to open a safety valve of the proper size to reduce the pressure. In case of emergency I would smother the fire instead of trying to draw it, shut off the draft and increase the boiler feed and blow down when necessary until the pressure was no longer dangerous.

H. G. ROBERTS.

Seattle, Wash.

Using Shims Instead of Wedges

In the Jan. 9 issue is an excellent article by Edgar C. Barker, Sr., on using shims instead of wedges under engines, turbines and other machinery when installing. This idea of using leveling plates which are set and grouted before the bedplate is lowered thereon is all right when the base is machined in the shop. However, if this is a rough casting, I prefer wedges of wrought iron about six inches long and tapering from half an inch to a point and of a width anywhere from 1½ to 2½ inches.

I take exceptions to the manner of grouting machines as suggested by Mr. Barker, when he says "A convenient method of building a dam is to make a fairly stiff mixture of equal parts of fine sand and cement, and plaster between the bedplate and the foundation with this material. After setting over night, the main grouting can be poured."

The purpose of grouting under an engine or any other piece of machinery is to provide a substantial foundation for such a machine, and it cannot be done with certainty of success by damming up the grouting space at the edge of the base and pouring the cement

into this space from the inside or other convenient opening at a later time, for there is no means of knowing whether the grouting has filled up the space.

Also, by this method there is no way for the air to get out, which is quite an item in some forms of grouting, nor for the surplus water to work to the top. I believe that good work cannot be done by this method, especially where the area covered is large.

The writer has been grouting engines and other machinery for many years and has always used the time-honored plan of grouting from the outside, or at least placing the dam several inches outside of the base, whether the grouting is poured from outside or inside.

The manner of building the dam depends a great deal on the material at hand. Common brick laid flatways two high, in common lime mortar, about six inches from the base is a good idea. These bricks can be knocked loose the next day after grouting and the mortar easily scraped off. Boards, say, four inches wide, set on edge and formed about the base as required and suitably braced or weighted at intervals, are much used, and where the floor is irregular, they can be backed up with sand or gravel to prevent leakage.

The grouting should be poured in as rapidly as possible and worked inside with something flexible, such as hoop iron, willow switches, perforated strap iron, etc., until the movement of such rowelling on one side is noticeable on the other side of the base, if not over six or eight feet wide.

Pouring and grouting should continue until the cement is well worked in all around, and about an inch at least above the bottom of the casting. Seeing this on the outside is knowing for a certainty that the grout has been forced up into all the channels of the base and the irregularities of the casting. This assurance is impossible by the method suggested by Mr. Barker.

After grouting has set about eight to ten hours it can be cut along the edge of the casting if desired, with a common trowel or similar tool, and later on in the course of 36 hours or so, this surplus can be removed and thus leave a good job of cementing, convenient to fix against any kind of floor.

As to the proportions of sand and cement, this is a matter that requires good judgment, as sand and cement differ. With good cement and sand, all that is needed is a mixture that has cement enough in it to fill all the spaces between the grains of sand. Generally speaking, a mixture of half and half is too rich and is easily broken, as can be demonstrated by test blocks. And by the same rule the writer has found that, one thing with another, a proportion of two parts good portland cement and three parts clean sharp sand makes an ideal mixture. Even this is not a universal rule.

In some localities sand is perfect and in others it is so clayey that it almost worthless. Instances have been found where it was necessary to wash the sand to remove the clay in order to insure a good job.

Of course, the ideal way to grout a bedplate, and especially a large one, is to have a power mixer in such a position that the mixture can be run down troughs to the several locations in quantities so that it will be forced into all parts of the space before it has time to settle. If necessary to wheel the grouting material some distance, it should be kept thoroughly stirred while pouring.

A pail, though often used, is a sloppy contrivance and permits the thin material to run out first and leave the thick grout in the pail. It usually spatters everything with cement which is sometimes a great disadvantage. A good device to use for pouring is a common scoop-shovel, and if the grout has to be mixed by hand, locate the mixing box close by, and while the material is being stirred or kept in motion, it is easily scooped up and put into the form without any settling.

Before making the dam, wash the top of the foundation in under the casting with a good hose so that all loose sand and dust will be washed out and permit good contact. Then just before pouring the grout, turn in a little more water.

As to leaving the wedges under an engine, it is best to remove them, if possible, on general principles, by tapping sideways about the second or third day after grouting, and in a week they can be withdrawn entirely. A wrought-iron wedge is preferable to a cast one, as the latter is easily broken under strain or in withdrawing. Holes in the grouting can be easily repaired.

However, if they cannot be withdrawn, let them stay. There are many engines and other machines running successfully setting on wedges. If the grout is well worked up into the channels of the frame or base plate, and the cementing is thoroughly done, the machine will run indefinitely. Pull the foundation bolts down after the grout is set, say, in about a week. Don't try to stretch the bolt; it cannot be done. Draw them up snug and hit the wrench a few sound cracks with a sledge.

The foundation-bolt problem is overdone many times. The writer has put in several engines with nothing but bruise bolts about four feet long to "hold them down," if one can conceive of their moving. On one occasion, while running a 50 per cent overload test for eight hours, all of the foundation bolt nuts were loosened a few turns to satisfy an over-officious master mechanic that the engine was without vibration. A new lead pencil stood on the cylinder during the remainder of the test.

GEORGE H. WALLACE.

Racine, Wis.

Does the Air Lift Push or Pull the Water?

The article by Frank Richards, "Does the 'Air Lift' Push or Pull the Water?" in the Jan. 30 issue, clearly demonstrates the action of air in an air-lift pump.

The question has often come up as to the reason why the water level in a steam boiler rises when steam is suddenly used in large quantities. One frequently hears the argument that the water level should drop after a large amount of steam is used because water certainly leaves the boiler in the form of steam. But the level invariably rises!

After a careful reading of Mr. Richards' article and thinking of steam bubbles instead of air bubbles, it will be readily understood by any reader why the level in the boiler rises. When steam in large quantities is taken from a boiler, the pressure naturally drops to some extent, and with a drop in pressure there is an increase in the size of steam bubbles because volume is inversely proportional to pressure, as explained so clearly by Mr. Richards. These larger bubbles displace the water in the same way that the air bubbles displace water, and the level in the boiler therefore rises. Then as soon as the pressure gets back to normal, the size of the steam bubble also goes back to normal and the level drops—possibly beneath the original level, depending upon the time required for the pressure to get back to normal and upon the amount of steam used.

FRANK M. REILLY.

Newark, N. J.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Increasing Speed of Corliss Engine

How can the speed of a Corliss engine be increased from 82 to 110 r.p.m. without changing the size of either the governor receiving pulley or its driving pulley? R. L. N.

By increasing the dead weight loading of the governor, the r.p.m. of the engine would be increased from requiring more speed for the governor to rise to a point that will obtain cutoff that is appropriate to the load. However, without trial and careful consideration it should not be assumed that the releasing gear of the cutoff mechanism and other working parts of an engine designed for 82 r.p.m. are adapted to operating with the speed increased to as much as 110 r.p.m.

Motor-Driven Compressor Should "Run Under"

Should a horizontal motor-driven ammonia compressor be run under or over? P. J. S.

In order that the pressure from the crosshead on the guides may be downward, a horizontal motor-driven compressor should be run under. In the case of a compressor the crosshead is driven by the crank, which is the reverse of the condition with an engine, where, to bring the pressure of the crosshead downward, the engine must be run over. By running a motor-driven compressor "under" or an engine "over," the wear is almost entirely on the lower shoe of the crosshead and, to maintain good alignment, this shoe alone will need adjustment.

Trouble from Priming

Considerable trouble is experienced with a steam threshing engine "pulling" water from the boiler over to the cylinder. The valve setting appears to be all right. How can the fault be remedied? C. J. G.

The priming over of water is no fault of the engine, but arises from wetness of the steam furnished by the boiler from foaming due to use of dirty feed water, having oil in the boiler, carrying the water level too high, driving the boiler too hard, or insufficient steam space in the boiler. When there is insufficient steam room and especially when the steam disengaging surface of the water is small, the steam space becomes filled with unbroken bubbles of steam which entrain much water as they are swept into the steam supply pipe to the engine.

Foaming may be caused by any materials dissolved or suspended in the water which retard or interfere with the free escape of steam from the water in the boiler. A collection of scum on the surface of the water is also a common cause of foaming that may be due to oil, vegetable matter or sewage collecting on the surface. If the water contains an alkali and any animal or vegetable oil becomes mixed with it, the alkali will change the oil into soap which forms suds with foaming. Foaming may be caused also by concentration of salts in the boiler that become precipitated in the form of a fine powder. This may be prevented by frequently blowing down the boiler and refilling with fresh water.

To compensate for insufficient steam space, the steam should be drawn through a liberal-sized steam drum and a separator should be placed in the steam line near the engine throttle valve.

Knock in Engine Attributed to Loose Crank

We recently purchased a second-hand slow-speed engine which since placed in use has a peculiar knock that appears to be due to looseness of the crank on the shaft. The shaft is steel 5 in. diameter and the crank is cast iron 4 in. thick. Would it be advisable to attempt electric welding without removing the shaft and crank from the premises? W. T.

Ordinarily electric welding could not be satisfactorily performed unless at greater loss of time and expense than necessary to remove and rebore the crank, upset and refinish the end of the shaft and replace the crank with a good press fit. However, before deciding on the necessity for such a repair, it should be borne in mind that looseness of the crank would have grown worse so rapidly with continued use of the engine as to render the condition unmistakable in a very short time.

Frequently a creaking noise or peculiar knock existing in an engine for a long time is attributed to looseness of the crank, and later it is discovered that the noise proceeds from some quite remote part of the engine.

Chloride of Calcium Solution

What is meant by a 2 per cent chloride of calcium solution, and what quantity of chloride of brine would be obtained from a gallon of water when sufficient chloride of calcium is added to make a 21 per cent solution? M. P. T.

A 21 per cent solution is obtained by dissolving 21 parts by weight of calcium chloride in 79 parts by weight of water. A cubic foot of water at 64 deg. F. weighs 62.3446 lb., and a gallon of water at that temperature weighs $62.3446 \times 231 \div 1{,}728 = 8.334$ lb.

The specific gravity of a 21 per cent calcium-chloride solution taken at the same temperature is 1.178, and therefore a gallon of the solution would weigh $8.334 \times 1.178 = 9.8174$ lb. A 21 per cent solution made from a gallon of water would contain $8.334 \times 21 \div 79 = 2.215$ lb. of calcium chloride and 8.334 lb. of water, making a total weight of 10.549 lb., and therefore the volume would be $10.549 \div 9.8174 = 1.075$ gallons.

Operating a 25-Cycle Induction Motor on a 60-Cycle Circuit

In changing a three-phase 25-cycle 750-r.p.m. 4-pole induction motor to operate on 60 cycles as a 6- or 8-pole motor, what change in voltage should be taken into consideration due to the overlapping of coils in the poles? H. E. W.

The voltage should vary directly as the chord factor which is the sine of one-half of the angle in electrical degrees spanned by the coil, and is given in the table. To quote a specific example, if a 4-pole 25-cycle motor has 48 slots, then 12 slots equals 180 electrical degrees and a coil throw of 1 and 13 would be full pitch, in which case the chord factor would be 1. If the winding is changed and the coils are put in so as to have a throw of 1 and 10, these coils span 9 slots. Therefore, since 12 slots equals 180 electrical degrees, 9 slots equals $\frac{180 \times 9}{12} = 135$ electrical degrees. In the second case the chord factor corresponds to 135 deg. equals 0.92.

CHORD FACTOR CORRESPONDING TO COIL PITCH IN DEGREES

Pitch of Coil in Deg.	Chord Factor	Pitch of Coil in Deg.	Chord Factor
180	1.00	130	0.906
170	0.996	120	0.866
160	0.985	110	0.819
150	0.966	100	0.766
140	0.940	90	0.707

Then if the original voltage was for 220 volts the voltage in the second case would be $\frac{220 \times 0.92}{1} = 205$ volts.

Now assume the second winding with a throw of 1 and 10, is to be reconnected for 6 poles and 60 cycles. Then $48 \div 6 = 8$ slots $= 180$ electrical degrees. Since the coils are wound 1 and 10, they span 9 slots, but 8 slots $= 180$ deg., therefore 9 slots $= \frac{9 \times 180}{8} = 202\frac{1}{2}$ deg. Over-chording the coils has the same effect as under-chording. In this cause the coils are over-chorded $202\frac{1}{2} - 180 = 22\frac{1}{2}$ deg., which has the same effect as if the coils were spread $180 - 22\frac{1}{2} = 157\frac{1}{2}$ deg. Therefore the chord factor from the table is about 0.975. Winding the motor for 6 poles 60 cycles will have a theoretical speed equal to 120 multiplied by frequency divided by number of poles, or $120 \times 60 \div 6 = 1{,}200$ r.p.m. Therefore, the total change in the voltage, considering difference in speed and difference in chord factor (assuming same phase) would be

$$\frac{220 \times 1{,}200 \times 0.975}{750 \times 0.92} = 372 \text{ volts,}$$

which is to say, if the 25-cycle 4-pole motor were 10 hp. and had 48 slots and the coils were wound in slots 1 and 10 when it was operated on 220 volts—then if it were reconnected for 6 poles 60 cycles and everything else left the same, it would give approximately the same performance as regards heating, power factor, and efficiency at 17 hp. and 372 volts, the horsepower varying as the voltage. If the machine is a squirrel-cage motor, it would not have so good a starting torque, because the squirrel cage and end rings are now of too large a cross-section for the new conditions. However, if the motor started light, this might be O.K. and would be worth a trial before turning the rings to smaller cross-section or making any changes on the rotor.

Similarly, if the original 10-hp. 4-pole 25-cycle 220-volt motor with 48 slots and a coil throw of 1 and 10 is reconnected for 8 poles and 60 cycles, then $\frac{48}{8} =$ 6 slots $= 180$ electrical degrees, and since the coils span 9 slots (that is 1 to 10) $\frac{9}{6} \times 180 = 270$ electrical degrees, and the chord factor corresponds to an angle of $180 - (270 - 180) = 90$ electrical degrees equals 0.707. Since the new speed is $\frac{120 \times 60}{8} = 900$ r.p.m. and the old speed 750, the new voltage considering everything will be $\frac{220 \times 900 \times 0.707}{750 \times 0.920} = 203$ volts. and the horsepower for same approximate performance would be $\frac{10 \times 203}{220} = 9\frac{1}{4}$.

The reason why the horsepower was increased on 6 poles and reduced on 8 poles is that on the 8-pole connection the coils are so much overthrow—that is, wound 1 and 10 when exact pitch would call for 1 and 7—that this feature is seriously interfering with the capacity of the motor.

Supporting Oil-Engine Piston for Removal of Crankpin Bearing

In a recent issue of *Power* the method of finding the clearance of oil-engine crankpins was discussed. How is the piston supported while the crank is turned enough to separate the bearing from the pin? G. N. S.

The engine should be turned to top dead center. If the engine has a crosshead, a hole should be drilled in

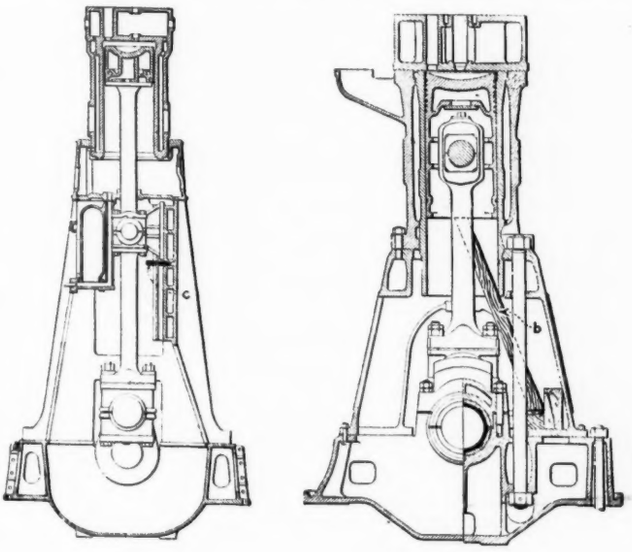


FIG. 1 FIG. 2

METHODS OF SUPPORTING OIL ENGINE PISTONS

one of the shoes in line with the lower edge of the crosshead shoe, as shown at *c* in Fig. 1. A pin is inserted in this hole and supports the weight of the piston, rod and crosshead. The crankpin bolts may now be slackened and by turning the shaft past dead center, the crankpin will force the two halves of the bearing apart.

In case of trunk-piston engines, a wooden scantling may be used to support the piston, as shown at *b* in Fig. 2.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses.—Editor.]

Easy Lessons in Engineering

How to Use Engineering Formulas

A formula is nothing but an abbreviated rule for solving a mathematical problem. Take for example this rule: *"Total cost of coal equals cost of one ton times number of tons."* To save time and space we might abbreviate this, using the letter C for the total cost of coal, c for the cost of one ton and T for the number of tons. Here C naturally suggests *big cost*, c *small cost* and T *tons*. The rule, in abbreviated form, then becomes: $C = c \times T$. This may be still further abbreviated to $C = cT$, since there is a common understanding in mathematics that two quantities placed side by side are to be multiplied if no other operation is indicated.

In this case it took no particular mathematical knowledge to make the rule and turn it into a formula. The reverse is often true in engineering work, some formulas being very difficult to derive. Yet—to use an analogy—a man does not have to be able to build an automobile in order to run one. He may even get along after a fashion without understanding the exact functions of the various parts of the machine. In the same way an engineer may use a formula that he could not derive and even does not fully understand. Of course it is better to know the inner meaning of the formula, just as it is better to have a good mechanical understanding of your automobile, but occasions arise when results must be obtained quickly and when an unfamiliar formula—which must be taken on faith—is the only way out.

Let us assume, then, that we have forgotten any algebra we ever studied, but have fortified ourselves against an emergency by accumulating a working library of engineering books including, say Mark's "Mechanical Engineers' Handbook" and Croft's "Steam Power Plant Auxiliaries and Accessories." Being suddenly called upon to figure the capacity in gallons of an odd-sized cask, we turn to "Casks, volume of" in the index of Mark's Handbook and are referred to page 110, where we find the following formula: $G = 0.0034\,n^2h$, and the statement that this is an approximate formula in which:

G = Number of gallons;
n = Average of diameters at top and bung, inches;
h = Height, inches.

It is then evident that this formula is merely an abbreviated statement of the following rule: The number of gallons in a cask is approximately equal to 0.0034 times the square of the average of the top and bung diameters times the height, all measurements being in inches.

The cask is measured with the following results: Top diameter = 24 in.; bung diameter = 30 in.; height = 36 in. To get the average of the two diameters, add and divide by 2 as follows: $24 + 30 = 54$; $54 \div 2 = 27$ in. Then, replacing the letters in the formula by the actual figures, we have:

$$G = 0.0034 \times 27^2 \times 36 = 0.0034 \times 27 \times 27 \times 36$$
$$= 0.0034 \times 729 \times 36 = 0.0034 \times 26{,}244 = 89.2\ gal.$$

Now let us try using a formula that is a little more difficult. The following is taken from page 242 of Croft's "Steam Power Plant Auxiliaries and Accessories":

$$A_f = \frac{W_f(T_{f_2} - T_{f_1})}{U\left(T_{fs} - \frac{T_{f_1} + T_{f_2}}{2}\right)}$$

This formula enables one to figure the amount of heating surface required for a closed exhaust-steam feed-water heater. The symbols have the following meaning:

A_f = Total heating surface of the tubes, sq.ft.;
W_f = Weight of feed water to be heated, lb. per hour;
T_{f_1} = Temperature of entering water, deg. F.;
T_{f_2} = Temperature of leaving water, deg. F.;
T_{fs} = Temperature of exhaust steam, deg. F.;
U = A special number or "coefficient" whose value depends on the kind of heater.

Now suppose that the particular conditions are as follows: A_f = ? (to be found); W_f = 12,000 lb. per hour; $T_{f_1} = 70$ deg. F.; $T_{f_2} = 200$ deg. F.; $T_{fs} = 212$ deg. F.; and $U = 350$, the "coefficient" given in the book for a multiflow heater with plain brass water tubes. The first step is to replace the symbols in the formula by the actual figures as follows:

$$A_f = \frac{12{,}000(200 - 70)}{350\left(212 - \frac{200 + 70}{2}\right)}$$

This is next solved by a process of simplifying, starting from the "inside" and working out.

The placing of 12,000 beside the parenthesis in the numerator means that 12,000 is to be multiplied by the difference between 200 and 70. The first thing to do is to subtract 70 from 200, giving $(200 - 70) = (130)$. In the same way the fraction in the denominator reduces to $270 \div 2 = 135$ and the lower parenthesis becomes $(212 - 135) = (77)$, giving the following:

$$A_f = \frac{12{,}000(130)}{350(77)}$$

We now see that A_f is equal to a fraction whose numerator is $12{,}000 \times 130 = 1{,}560{,}000$ and whose denominator is $350 \times 77 = 26{,}950$. Then:

$$A_f = \frac{1{,}560{,}000}{26{,}950} = 57.9\ sq.ft.$$

The same general method applies to other formulas. Start by putting the actual known values in place of the symbols or letters. Then perform the indicated arithmetical operations, working from the inside out. A later article will show how to turn a formula around when the unknown quantity to be found happens to be on the right-hand side.

Central-Station Development in Chicago

Samuel Insull, President of Commonwealth Edison Company, Outlines the Advance of the Last Thirty Years at Banquet of Western Society of Engineers

ON THURSDAY, FEB. 1, the Western Society of Engineers held its second midwinter convocation, to afford its members an opportunity of becoming familiar with some of the engineering problems now confronting Chicago, such as water supply, fire prevention, sewage and power development. During the day the following addresses were given: "The Chicago Sewer System," by George C. D. Lenth; "Sewage Disposal and the Chicago Problem," by Harrison P. Eddy; "Present and Future Plans of the Sanitary District of Chicago," by Langdon Pearse; "Water Supply of the City," by Dabney H. Maury; "What Metering Would Do for the Chicago Water Works," by Louis R. Howson; "Present and Future Plans of the Chicago Water Works," by Myron B. Reynolds; and "Fire Protection for the City of Chicago," by Clarence Goldsmith.

A feature of the program was a dinner meeting at the Hamilton Club, at which Samuel Insull, president of the Commonwealth Edison Co. reviewed in a most interesting and intimate way Chicago's central-station development from 1892 to 1922 and intimated the prospects for the future.

Beginnings of the Industry

Some thirty years ago, owing to the vicissitudes of the electrical manufacturing business, Mr. Insull was looking for some place to manufacture and distribute electrical energy rather than the manufacture and distribution of electrical apparatus. He was looking for a place where the central-station business had been developed the least and where the opportunities were the greatest. About that time the old Chicago Edison Co. had asked the speaker to look for a president, and according to his own statement, Mr. Insull had the temerity to suggest himself. With its great transportation facilities both by water and rail, he believed that Chicago must become a great manufacturing center and, as a consequence, a great center for electrical distribution. His hopes of thirty years ago have been borne out, for the present demand and the future development of electric power in sight pointed to Chicago eventually as the biggest industrial center in the world.

In 1892 the old Chicago Edison Co. had less than one-half of the central-station development of the city. At that time it had two small stations with an aggregate capacity of 3,180 kw. The Chicago Arc Light & Power Co. had 3,500 kw., making a total of 6,680 kw. for the city.

The first station on the multiple arc system had been built in New York in 1882. Six years later similar equipment was installed in Chicago at the Adams Street station. Four high-speed engines, each driving two Edison bipolar dynamos of 80 kw. each, were installed and the area served was about ¾ mile. The next station was on Wabash Avenue at Twenty-Seventh Street. It began operations in 1891 and was shut down in 1907. The equipment was similar to that at the Adams Street plant, consisting of engines belted to generators. This plant finally attained a capacity of 550 kw. It was interesting to recall that in this plant was installed the first rotary converter ever ordered. Owing to financial exigencies it was not the first, however, to be placed in operation. With the exception of the steam turbine this piece of apparatus, in the opinion of the speaker, had more influence than any other one thing in the general development of electrical generation and distribution. The installation on Wabash Avenue was to be considered the first milestone in the electrical development in Chicago and all great centers of population today the world over.

Continuing the review, the first large development in Chicago was the old Harrison Street Station, which was the largest plant in the West and in its day the most efficient plant in the country. Work on this station was started in September, 1892. It was one of the four plants in the country at that time using marine-type engines directly connected to dynamos. It had an active life of 16 years and during that time generated 534,783,000 kw.-hr. which was practically one-quarter of the Commonwealth Edison output in 1922. At the time the station was shut down, the capacity had reached a total of 17,000 kw., which is less than one-third of the kilowatt rating of one of the prime movers now on order. The size of unit had reached 5,000-hp., or 3,500 kw.

First Turbine Station Built in 1903

About this time the steam turbine began to receive attention. The New York Edison Co. imported a small Parsons turbine, and soon after, toward the end of 1901, the General Electric Co. asked to install a 1,000-kw. Curtis turbine in Chicago. They had been experimenting with a 500-kw. unit at Schenectady. This, however, was considered a step backward, as engine units of 3,500-kw. capacity were already in operation, and it was finally agreed to increase the capacity of the turbine to 5,000 kw. After much consideration the Edison company decided to venture a turbine station as additional capacity was badly needed. In June, 1902, ground was broken for Fisk Street Station, and the first 5,000-kw. turbo-generator was in operation by October, 1903. Two other units of the same size soon followed and a fourth of the same type, but having capacity of 7,500 kw. was installed in 1904. The reminiscences of the speaker relative to the starting up of the first unit were most interesting, for the success or failure of this experiment meant everything to the company at that time.

These first four turbo-generators ran only about five years when they were replaced with 12,000-kw. machines, which were placed on the same foundations and served by the same boiler plant, this latter fact indicating the great improvement in economy.

To illustrate the difference between a company whose prime business was to manufacture electrical energy and one in which it was merely an incident, Mr. Insull referred to the plant of the New York Central Railroad, which had been equipped with turbines of the same type as the No. 4 unit at Fisk Street. The central station could not afford to use this type of machine more than five years, whereas the New York Central went on using these turbines up to the present time. The saving in coal would have warranted many times over the exchange to more modern and economical machines.

Plans for the Future

Fisk Street grew to its present capacity of 230,000 kw.; other stations were built, including Quarry Street, with a capacity of 84,000 kw., and Northwest Station, started in July, 1912, which now has a rated capacity of 165,000 kw. The next step was the building of Calumet Station, for which ground was broken in 1920 and which by the end of the present year will have a capacity of 200,000 kw. in six units.

The growth in the use of electrical energy had been so great that the company was now compelled to build on even a larger basis. Ground is now being broken for the new Crawford Avenue plant, which probably will have ten units to develop 400,000 kw., although the chances are that the final capacity of this station may be 600,000 kw. or more. The first two units will generate 90,000 to 95,000 kw., one of these units being a Parsons machine from England and the other a Westinghouse unit. The steam pressure is to be 600 lb.

As a matter of engineering interest Mr. Insull reviewed the developments that had been made step by step from one

station to another in size of unit, the steam pressures employed, and the reduction in fuel requirements per kilowatt-hour. For convenient reference these data appear in the accompanying table:

DEVELOPMENTS IN UNIT SIZE, STEAM PRESSURE AND COAL ECONOMY IN CHICAGO'S CENTRAL STATIONS

Stations	Size of Units, Kw.	Steam Pressure, Lb. Gage	Coal, Lb. per Kw.-Hr.
Adams Street	80	125	12
Wabash Avenue	200	125	12
Harrison Street	800		
	3,500	175	6
Fisk Street	5,000		
	30,000	200	2.75 to 2
Northwest	20,000		
	35,000	250	2
Joliet	10,000	300	1.8
Calumet	35,000	325	1.8
Crawford Avenue	50,000	600	1.5

Starting with units of 80 kw. at the original Adams Street Station, a gradual increase had been made up to 50,000 kw. per unit for the Crawford Avenue plant. Steam pressures had been built up from 125 lb. to 600 lb., and in the near future it was probable that they would go to a thousand pounds, as the company had the call on a boiler and small high-pressure turbine unit built for this pressure. The coal consumption had been reduced from 12 lb. per kilowatt-hour at the Adams Street Station to 1.8 lb. at the Calumet and Joliet plants and it was hoped that at the Crawford Avenue plant it would be further reduced to 1.5 lb. or 1.6 lb. per kilowatt-hour.

To show the effect of this reduction in coal consumption the speaker referred to the Public Service Company of Northern Illinois, which uses 400,000 tons of coal a year. If the economy had been no better than that of thirty years ago, the annual consumption of this company would have been 2¼ to 2½ million tons, and of the Commonwealth Edison Co., which now uses about 2½ million tons of coal per year, the consumption on the old basis would have been 15 to 18 million tons in the same period.

How Economy Was Effected

The improvement had not been due merely to increase in steam pressure, for in the Adams Street and Harrison Street stations the coal consumption had been cut in two by the use of condensers. From Harrison Street to the Calumet Station the better economy was to be attributed to steam-turbine improvement and to a vacuum of 29 in. as compared to 26 in. In this connection the speaker referred to the great quantities of water required. From 400 to 450 tons of water was pumped through the condensers for every ton of coal burned in the furnaces. Through its condensers the Commonwealth Edison Co. pumped more water than the City of Chicago used for all purposes. Other factors influencing the reduction in coal consumption were the marked improvements in furnaces and stokers.

From the financial viewpoint economy had been effected by mass production and the transmission of large masses of energy at high pressures. One important factor in distribution was the diversity of demand obtained by combining loads of different character, such as light and power, street-railway service, isolated plants and electrified steam railways. The total demand in 1912 in the Chicago area amounted to 628,510 kw. Due to the diversity factor, this reduced to a coincident demand of 556,250 kw., a saving of 72,260 kw. With all steam railroads electrified the total maximum demand would now be 1,110,500 kw. The diversity would amount to 151,000 kw. and reduce the total load to 959,500 kw. This 151,000 kw. figured at $100 per kilowatt and allowing 25 per cent reserve, represented an investment of $18,120,000 saved in generating equipment. Including the surrounding districts a diversity of 170,000 kw. would be obtained, representing a reduction of investment approximating $20,000,000.

To illustrate the rapid progress that is being made, Mr. Insull pointed out that the maximum demand for 1922 was nearly 800,000 kw. Allowing a 10 per cent increase per year over the next six years and not including electrification of the steam railroads, there would be in 1927 in Northern Illinois and a small portion of Northern Indiana a demand of 1,500,000 kw. Before next winter the actual station capacity would be 1,021,000 kw. Of this the Commonwealth Edison would have 770,000 kw., the Public Service Company of Northern Illinois 150,000 kw., the Illinois Northern Utilities Co. and others in the northeastern Illinois districts 101,000 kw. In addition the company actually has in contemplation and the finances have been arranged for 1,150,000 kw., making the total capacity now in sight 2,171,000 kw. This was to be made up of 400,000 at the Crawford Avenue Station, 100,000 kw. at Joliet, 150,000 kw. at Waukegan, and 500,000 kw. in another large station for which ground has not yet been broken. This additional capacity would be absorbed in about eight years.

In analyzing a few of the elements that have made possible such a large aggregation of electrical energy in this part of the country, Mr. Insull gave as the fundamental reason the method of selling large volumes of energy to large wholesale consumers. In the Chicago districts his company generated 50 per cent more energy, and while receiving for it one-fifth less money, made more profit on the dollar invested than any other large power company in the world.

True engineering of selling plus true engineering in distribution had forced the development of the steam turbine, and was responsible for the great development in the Chicago region. This had been a natural development, achieved by improving economy in station after station in the last thirty years.

In conclusion, the speaker could conceive of no more fitting place in which to pay tribute to the great central-station designing engineer, Fred Sargent. If the speaker had contributed anything to the commercial development of the company, Fred Sargent had contributed more than any other man as a designer and builder of the great central stations of Chicago.

Generation of Steam by Electricity*

By Philip H. Falter†

The electric steam boiler, or generator, is not exactly new, having been used in various parts of Europe during the last sixteen years, but its use on this side of the Atlantic began, on a commercial scale, somewhat over two years ago. In Europe, after sixteen years it is only beginning to be employed in a really large way, and none of the units now in use approaches in capacity some of the large units now running in this country and in Canada.

The development of the electro steam generator was started in America by a condition resulting after the ending of the World War. At Shawinigan Falls, Quebec, the Shawinigan Water & Power Co. built during the war a large chemical plant, the business of which was, and still is, conducted in the name of the Canadian Electro Products Co., Ltd. After the armistice this company had to find business to keep it in existence. Steam was required in winter even when not operating in order to preserve the property. Coal was brought from Pennsylvania at continually increasing cost. At the same time the business of the power company had fallen off so that it had idle generating machinery and large volumes of water going to waste over Shawinigan Falls.

It was finally realized that steam for the chemical plant could be obtained for almost literally nothing if it could be generated electrically. The generating capacity and water were available and transmission lines ran to the chemical plant, so that only the steam generators were lacking. It was difficult in the first place to get the small appropriation for the project, and then, strange as it may seem, it was found that the European manufacturers were indifferent. They had only small units to offer, loaded up with so-called automatic devices, their prices were enormous, and their deliveries discouraging. It was then decided to design a simple rugged electric boiler free from complicated mechanism, but which would effectively make use of the

*Abstract from a paper presented before the Philadelphia section of the Association of Iron and Steel Electrical Engineers, Feb. 3, and Franklin Union, Boston, Mass., Feb. 6.

†Vice-president, The Electric Furnace Construction Company.

electricity available. F. T. Kaelin, chief engineer of the Shawinigan Water & Power Co., and the writer[1] designed and put into operation the first experimental unit, which after some alterations proved satisfactory.

Passing over development details, there are today in use or under construction in this country and in Canada boilers or water heaters of the Kaelin development aggregating over 200,000 kw., their operating voltages range from 220 to 22,000, single phase, two phase or three phase. Steam pressures range from 4 lb. to 220 lb. gauge, with capacities up to 35,000 kw.,[2] and water heaters up to 720 gal. per min., operating under pressures up to 100 pounds. Aside from the boilers built for the Canadian Electro Products Co., Ltd., the first large unit is that in the paper mill of the Belgian Industrial Co. at Shawinigan Falls. This unit was started at the end of Sept., 1921. Thus practically the entire capacity has been installed or undertaken during the last sixteen months.

Methods of Making Steam Electrically

There are three recognized methods of heating water electrically; indirectly, direct resistance and the electrode method. The indirect method is most familiar. The heating element is encased in a water-tight tube which is immersed in water. In the second method, bare wires, ribbons or rods carrying current are immersed in the water. Third, the so-called electrode method, which might more properly be termed the direct-resistance method since the resistance of the water itself causes the heating as the current flows through it from electrode to electrode, or from the electrodes to the grounded neutral. The elements in the first two types must be at all times immersed to prevent burning out. Both kinds depend also on insulation to prevent short-circuiting and grounding. Their usefulness is therefore limited to equipment of low capacity.

The electrode or water-resistance method, though not a sure cure for all electrical water-heating troubles, lends itself to such a wide range of applications that its development is extremely interesting. The capacity of units may range from the smallest to the 35,000-kw. boilers now in use. Boilers of 50,000 kw. are now under consideration for two large projects. There is no reason why 100,000-kw. units should not be used. The operation of such a unit is as easy as the operation of one of 1,000-kw. capacity. A single attendant per shift could easily look after two or three such units, since his principal and almost only duty is to vary the water level to follow the steam demand.

Water-Resistance Type Simple To Operate

In its simplest form the water-resistance heater is nothing but a water rheostat. Each is very nearly perfect in efficiency; the latter in wasting energy and the former in turning it to profitable use. It is clear that the energy put into an electric boiler or water heater all goes into the water. The only losses that are possible therefore, are radiation, which can be kept low by proper heat insulation, and a small loss from bleeding or blowing down to get rid of the impurities left behind when the water is evaporated. Therefore the opportunity for inefficiency as a result of carelessness on the part of the attendant or total lack of attendance is very small.

The proper design of an electric boiler or water heater requires careful attention. First, all boiler-code rules and special state regulations must be complied with. There are atmospheric pressure, water-service pressures, and low, standard and high steam pressures. In the case of new equipment the selection of correct operating voltage may have an important bearing on the efficiency of the boiler. The question of current densities is also important. A boiler that will meet one condition of water may not be suitable for another. Even the frequency employed influences the design.

Boiler-feed waters vary greatly in electrical conductivity on specific resistance and must be as carefully taken into consideration as the chemical qualities where used in fuel-fired boilers. The adding of chemicals to electric-boiler feed waters is to be avoided. Even in Europe, where doping the water to change its resistivity was once in general use, the practice is now frowned upon.

One of the most difficult questions to decide in the design of our electric boiler was the question of automatic devices. The fact that the height of water in the tank controls power input and thus the amount of steam generated, renders a boiler so nearly self-automatic that additional automatic-control equipment was found merely to complicate the operation, with no corresponding advantages. It was found that most of the so-called automatic devices had the habit of failing at the critical time and the accessories often require more attention than the main apparatus. On the large boilers a man is always in attendance on one or more boilers, and it is a simple matter for him to keep watch on the water levels. Automatic devices and other complications as applied to electric steam boilers are new sources of possible trouble and likely to destroy the simplicity of the whole job.

There is little that can go wrong in a properly designed electric boiler. On high voltages insulators give some trouble and electrode wear must be allowed for. Neither item is serious as affecting the safety of the boiler, and repairs can be made quickly and cheaply. In addition to the usual safety valves required by the Boiler Code, automatic circuit breakers, or in small boilers, fuses are employed to cut off the current if it goes too high. The condition of low water, so much feared in other boilers, merely means a lower steam production, and should the water go below the ends of the electrodes no current can flow and the boiler is shut down.

First Boilers Used at Shawinigan Falls

In our first boilers at Shawinigan Falls, we employed iron plates bent to the arc of a circle and suspended from the conducting rods within the boilers so as to hang concentric, and thus parallel with the neutral shell which formed a protective lining for the boiler shell proper. This construction, while fair, does not lend itself to adjustments which are sometimes necessary. The round electrode was also employed, but is not as satisfactory as the concentric method from the viewpoint of definite calculation of current distribution. Both of these methods are for use in the smaller boilers up to 7,500 kw., and for voltages up to 2,300.

For higher capacities and particularly for higher voltages, the multiple tank design is generally used. It is equally satisfactory for small boilers, but is somewhat higher in first cost. For three-phase power three tanks are used and two tanks for a two-phase supply. Each tank is a separate single-phase boiler having one cylindrical electrode suspended in its center by one or more supporting rods or cables which serve to bring in the current. The water supply and bleed for each tank are independently manipulated so as to keep the same amount of power flowing through each and thus to balance the phases on a polyphase system. The steam is piped into a common header.

The designs or types of small boilers or water heaters are too numerous to cover at this time. The designs vary more because of their application to a particular purpose than in the boiler or heater proper.

The most natural place for the large electric steam producer is where hydroelectric energy is developed in excess of the more usual requirements, or where coal is expensive and water power is available. The electric boiler has made possible the development of certain pulp- and paper-mill projects in Canada and elsewhere, which would have proved uneconomical if coal had been necessary. Assume a paper mill requiring 3,600,000 lb. of steam in 24 hours; this would require about 47,600 kw. capacity. Assume that if produced from coal an evaporation of 9 lb. of water per pound of coal could be maintained. Then 400,000 lb. or 178.5 long tons, of coal would be required daily. At eight dollars per ton under the boilers, this would cost $1,428 per day, or $428,400 for a year of only 300 days. All these assumptions are in favor of coal burning and consequently the most difficult that the electric boiler would have to meet. Yet, if we capitalize the annual coal bill at 10 per cent for interest and depreciation, it will make possible the expenditure of ninety dollars

[1] At that time vice-president and general manager of the Canadian Electro Products Co., Ltd.

[2] For a description of these units see page 208 in the previous issue. At 125 lb. gage, with feed water at 200 deg. F., one kilowatt-hour will produce 3.23 lb. of steam, at 97 per cent efficiency.

per kilowatt for the hydro-electric plant which would displace coal. The plant would not need step-up or step-down transformers, if the generators are chosen of a voltage to suit the boilers. The transmission line would be very short. Probably much less than ninety dollars per kilowatt would be sufficient. At $75, for instance, it could compete with coal at $6.67, and at $60 with coal at $5.33 per ton.

In New England there are a great many places where streams have been dammed to develop a small amount of power with which to drive a mill. The rest of the water has gone to waste for generations. Yet all these mills require a certain amount of steam during the winter, and some of them have been burning coal the year round for the production of process steam on a small scale, where the additional power for producing this heating and process steam electrically could be obtained at small cost and make the mills' operation independent of coal.

Some large users purchase power in large blocks at a fixed rate per year.* Seldom do they approach a 100 per cent load factor. The electric steam generator, by using any surplus during the day or night, Saturday afternoons, Sundays and other holidays, produces a corresponding amount of steam almost literally for nothing if it is located in the boiler house. It quickly pays for itself by the saving in coal realized.

There are many industries and some institutions in which a small amount of steam or hot water is required at intervals, for which a coal-fired boiler must be kept in service. The greater part of the fuel is consumed while standing by. In such cases prevailing rates for electric power can often be paid and the steam or hot water produced at less cost than with coal. But here demand charges often prove too high. However, over-all costs of the two methods of production must be carefully compared.

Chicago Engineers Discuss Ammonia Condensers and Water Cooling

Three subjects were up for discussion at a meeting of the Chicago Section of the American Society of Refrigerating Engineers held on Jan. 30 in the rooms of the Chicago Engineers' Club. O. A. Anderson, of Armour and Company, presented a paper on "Ammonia Condensers," and the subject of water cooling was divided between Edwin Burhorn, of New York City, who had prepared a paper on "Cooling Towers," and B. R. Sausen, of the Binks Spray Equipment Co., whose subject was "Spray Cooling Equipment for Ice Plants." In the paper first mentioned Mr. Anderson outlined briefly the different types of condensers, including atmospheric, double-pipe, tubular and the submerged condensers. The relative advantages and disadvantages of each type were given, with comments following on the life of the equipment, means of cleaning, ammonia leaks, etc. These various points will be brought out in an abstract of the paper to be presented in an early issue.

In spray-cooling equipment Mr. Sausen pointed out that the determining factors were the nozzle design, the size of the nozzle used and the arrangement. Spray nozzles had been used for the recooling of condenser water in connection with steam plants for a number of years. The first nozzles were designed for high pressure, resulting in prohibitive operating costs, but had been superseded by low-pressure nozzles requiring only 4 to 8 lb. for sufficient atomization of the water. When first applying this method of cooling water to the ice plant, the arrangement, spacing of supply headers and the size of the nozzle were features that had not been given consideration, and the result was unsatisfactory cooling. However, all these points had been fully studied and worked out, so that spray systems were now giving excellent satisfaction for this service. The author explained briefly the difference between the full mass spray and the hollow conical spray and gave the characteristics of the rigid and adjustable types of spray nozzle. Of the various cluster groups of three, four, or five nozzles the five-nozzle arrangement was preferable, the group being spaced usually on 13-ft. centers with parallel supply headers at least 20 ft. apart, depending upon the spraying capacity of the cluster. Of the two types of louver employed, the horizontal and the vertical, preference was given to the former.

For a fixed amount of refrigeration the size of the spray system was usually based on spraying 4 gal. of water per minute per ton of refrigeration. This resulted in a temperature range of approximately 7 deg. and under such conditions a properly designed spray system would cool the water within 3 deg. of the wet-bulb temperature, the operating pressure being 7 lb. To substantiate this statement, results from a number of tests on different spray systems under severe summer conditions were presented.

Test data over a number of years favored the five-nozzle cluster arrangement, using 1¼-in. nozzles and having a spraying capacity of 100 gal. per min. The initial cost of such an installation, consisting of nozzles, clusters, wrought-steel piping and fittings over the spray deck, varied between 45c. and 55c. per gallon per minute. The cost of horizontal cypress louvers 10 ft. high, made up in 6-ft. sections, was approximately $22 per section. The vertical type of louver of equal proportions cost about 15 per cent less, these figures not including erection.

In the Burhorn paper, which was read by William Hennings, attention was given to some of the important factors in successful cooling-tower design. It was pointed out that in all kinds of atmospheric water cooling the main objectives were to obtain the actual heat abstraction and to retain the cooling water in the system. Experience had shown that an approach to within 5 deg. of the wet-bulb thermometer was readily obtainable where the temperature varied from 65 to 75 deg., and where the wet-bulb range was from 75 to 80 deg., an approach to within 3 deg. was feasible. A tower could be designed to cool the water to the exact wet-bulb temperature, but the cost would be prohibitive.

The author compared briefly the three main types of cooling tower—the fan, natural draft, and atmospheric types—of which the last-named was favored. Louver arrangement to prevent excessive water loss and water distribution in the tower were subjects given attention. Comparison was made between the cooling tower and the spray system and consideration given to some of the operating requirements such as temperatures range versus quantity of water pumped and the physical dimensions of the tower, all of which will be brought out in a more complete abstract of the paper to be presented later.

Discussion on the condenser paper turned to the insulating effect of paint on the piping, tests on piping given a coat of red lead having shown a difference of 2 B.t.u. per square foot of exposed surface. The benefit of welding to reduce leakage was emphasized. In a certain plant the return bends in 85 stands, 12 pipes high, had been gas-welded. Previously, the ammonia bill had been $2,900 per year. Since the welding was completed, there has been no occasion to buy ammonia for two years, and at the present there is still a full charge in the system. To an objection that insurance companies would not pass gas welding, it was pointed out that in the case referred to, 11,000 gas welds, some 5,000 of which were on the high-pressure side, had been made and not one failure had occurred.

On the two papers dealing with water cooling a point discussed was sun effect on the spray pond. It was agreed that this depended a great deal on the spacing of the nozzles and whether a flat or pitched roof was under consideration. To get the water away quickly, a considerable pitch to the spray deck was essential, and under these conditions the rise in temperature would be negligible. No very definite data were available relative to the difference in power required for pumping water to spray ponds and cooling towers.

Other subjects given attention were the spacing of nozzles, interference between sprays, wear and tear on the roof serving as a spray deck, and provisions for keeping cooling towers and spray ponds from becoming overloaded with ice in winter. In spray systems a bypass arrangement was provided whereby the water need not be discharged through the nozzles, and in some installations, as a means to the same end, calcium brine had been used in the water.

News in the Field of Power

May Postpone Ratifying of Colorado Compact

Doubt as to the ratification of the Colorado River Compact by Congress, at this session, has been expressed by Commerce Secretary Hoover. Delay on the part of Arizona and Colorado in securing ratification by their legislatures has precluded consideration of the compact by Congress sufficiently long to endanger ratification at Washington, due to the usual congestion of legislation at the close of a session, even if those states should take belated action.

Secretary Hoover emphasized the responsibility that those states are assuming in delaying works of flood protection and those necessary to the utilization of the resources of the river. He pointed out, however, that failure on the part of the legislatures of Arizona and Colorado as now constituted in no way impairs the existence of the compact itself, which can be ratified at any future time.

Heating and Power Plants for Michigan Cities

A 20,000-kw. plant at Zilwaukee and a central-station heating plant at Grand Rapids are included in preliminary plans for the 1923 power development of the Consumers Power Co., of Jackson, Mich. The Zilwaukee plant, to be built five miles north of Saginaw, will ultimately produce 60,000 kw. Taylor stokers, a Green induced-draft system, and B. & W. boilers operating at 375 lb. with 250 deg. F. superheat, will be used.

Low-pressure steam at 2 lb. and high-pressure service at 50 and 100 lb. per sq.in. for the downtown section of Grand Rapids will be supplied by the central-station heating plant, according to H. F. Eddy, mechanical engineer of the company. With a steam pressure of 350 lb. per sq.in., 250 deg. F. superheat, and non-condensing operation through 1,500-kw. and 3,000-kw. units, enough steam will be obtainable for heating 600,000 to 1,000,000 sq.ft. of radiating surface. The European Venturi type of stack will be used.

Few Engineers Unemployed

All indications point to a banner year for engineering employment, according to the employment department of the American Association of Engineers. Resumption of activities after the usual year-end pause is well under way. There is a great demand for engineers, particularly for designers, and an average increase on starting salaries amounting to over 10 per cent has become effective in many organizations.

In a survey of the country, practically all sections show very little unemployment among professional engineers, a scarcity of men for engineering work and office men are at a premium. Conditions on the Pacific Coast are excellent with the exception of the northwest, where the winter season has tied up construction work. The southwest section is fair and the mountain states are about balancing supply and demand. The central states show the greatest activity in engineering work with practically no unemployment and an average of two positions for every competent designing engineer. The Southern and South Atlantic States show activities fair, with some construction work starting and highway work taking on activity. The Eastern section shows some unemployment among engineers.

Western Engineers and A.S.M.E. Meet

Speakers Urge Greater Participation of Engineers in Public Life—Picture Societies as Forums for the Discussion of National Problems

THAT the engineer should not be satisfied to remain behind the scenes, restricting himself to his narrow scientific specialty, but should take a more active part in public affairs and merit the credit due him, instead of allowing it to pass to the military leader, the lawyer or the financial executive, was the keynote of the addresses of John L. Harrington, president of the A.S.M.E., and Charles Piez, president of the Link-Belt Co., at a joint meeting of the Chicago Section, A.S.M.E., and the Western Society of Engineers on Jan. 29.

Although the engineer has performed important functions throughout the ages, he has always been more of a doer than a talker, said Mr. Harrington. It was only in 1771, when a group of seven men organized the society of civil engineers, that the profession received its first real publicity. This society included all engineers as distinguished from other professions. There is too great a tendency, said the speaker, for the engineer to stand apart from other lines of endeavor. He is still a narrow scientific man, believing that his function is to deal with the definite technical questions in which he specializes. It is difficult for engineers to agree with other men, and even among themselves the differences of opinion are so great that although working along the same lines they often lose the benefits of broad co-operation, as shown by the existence today of some thirty-three different societies devoted to mechanical pursuits.

In President Harrington's opinion, it is essential that the engineer broaden out and take his real part in public affairs. For the great industrial developments of the day, the engineer is responsible, and yet he is still in the background of industry. In politics the engineer is even farther back. In civic affairs he furnishes the technical information but is satisfied to sit back and let politicians benefit from his knowledge and advice. The public has come to think of the engineer as a poor business man, when as a matter of fact he is generally more capable and honest than the average man, due primarily to the fact that he must face his problems honestly.

It is true, said President Harrington in closing, that the engineer would rather construct than contend. He must realize, however, that before this country can be assured of good government the engineering profession must face conditions as they are and do its part to bring about clean, honest politics.

Supplementing Mr. Harrington's remarks, Mr. Piez said that by reason of their training in analyzing problems, the various engineering societies should make excellent forums for the discussion of political questions. Among such questions today is that of the nationalization of railways and coal mines. The engineer holds the middle ground between capital and labor, and having no special jealousies nor political interests is well qualified to judge of the merits of the controversy.

What constitutes a proper wage is another broad question that might be considered. There are something like 40,000,000 workers in the United States, said Mr. Piez, and the wealth produced annually amounts to $40,000,000,000, giving an average return to each worker of $1,000 a year. Without a greater income, it is impossible to raise the average.

Another question is immigration, on which the present restrictions are proving embarrassing to industry, due to the shortage of common labor. Mr. Piez mentioned three solutions: Revision of the present statute, the substitution of mechanical devices for hand labor, and the shifting of men from over-manned industries to those in which shortages exist.

The findings of the Coal Commission make a fourth problem of public interest which should be carefully analyzed to see that the proper facts are brought

out and a satisfactory solution obtained. To these and similar problems, the engineering profession should give attention, and in so doing take a leading part in public affairs.

David Cochrane, Power-Plant Engineer, Passes Away

The death on Jan. 24 of David Cochrane, the inventor, designer and first builder of the open feed-water heater bearing his name, closes the career of a man whose ideas have resulted in the conservation of tons of coal in the United States and elsewhere. Mr. Cochrane was born in Scotland in 1850, and in his early years worked as a pattern-maker on the Clyde. In 1879 he came to this country, where he entered the employment of Ferris & Miles, but shortly afterward went with the Harrison Safety Boiler Works, then the builders of a sectional cast-iron boiler. His open heater, brought out in 1883, was specifically designed to protect boilers from the effects of cold, unpurified feed water and was itself the first to be built of cast-iron plates, to avoid corrosion.

Mr. Cochrane was also the first to design a successful oil separator, a heater and receiver and other power-plant appliances. He was distinguished by great common-sense in engineering matters and had a peculiar capacity for winnowing the wheat from the chaff and for simplifying construction. He was frequently consulted concerning the design of steam plants and his great contribution to steam engineering consisted in focusing attention upon the more efficient utilization of exhaust steam for heating buildings and for heating and purifying water to be used for feeding boilers and for industrial purposes. As early as 1894, he advocated the withdrawal of steam in course of expansion for feed heating and similar purposes, thus anticipating the present-day movement to provide all large turbines with bleeder connections.

Investigates Boiler Scale Problem

At the Pittsburgh, Pa., experiment station of the Bureau of Mines, a study is being made of the mechanism of scale formation in steam boilers, including the effect of temperature, pressure, character of surfaces, and concentration of the water. A continuous test is being conducted on a commercial boiler in actual operation, in which a part of the suspended matter is being continuously removed by an external filter through which the boiler water is circulated. A complete record and account of the scale-forming constituents is kept and the influence of added constituents noted.

Acceptance of Ford Offer Urged in House

Unqualified acceptance of Henry Ford's Muscle Shoals offer was urged in the House on Feb. 3 by Representative Madden, chairman of the Appropriations Committee. In his speech, which was interpreted by those who favored Mr. Ford's proposal as indicative of a definite purpose of the Administration to accept the offer, he declared that he was viewing the matter from a business standpoint and wanted to see the project put in the hands of a man of ability, regardless of politics. He was applauded by both sides of the controversy.

Until recently there has been a trend among government officials toward government operation of the Muscle Shoals plant, but of late the tendency has been the other way. House leaders said several weeks ago that they were ready to vote on the Ford proposal in this session.

Mr. Madden gave the cost of Muscle Shoals up to June 30 as $107,337,710. He said that in order to make a going plant it would be necessary to make additional appropriations of $59,000,000, which, with the $25,000,000 needed to complete the Wilson Dam, would bring the total outlay up to $191,000,000.

Under the Ford proposition, Mr. Madden said, the government would put up $50,000,000 to complete Wilson Dam and build Dam No. 3, which "would end the demands upon the Federal Treasury and be an investment of $157,000,000 instead of $191,000,000." In closing, he summed up the case as follows:

The question resolves itself into just this: Do you wish to sink another hundred million into the Muscle Shoals project, or do you think the wiser course would be to accept Mr. Ford's offer, putting only enough additional in the venture to complete both dams and sell the lease under the terms that he has proposed? My own conviction is that we should accept the Ford offer and get out of the business. I feel that by so doing we shall have acted so as better to provide for the common defense and for the promotion of the general welfare.

Study Superpower Further, Says Coal Commission

A FURTHER study of superpower will be recommended by the President's Coal Commission, it was revealed at the Feb. 3 conference with Washington correspondents. While it was admitted that mine-mouth use of coal has a limited application, due to the difficulty in securing condensing water, yet it is believed that much transportation of coal may be avoided by well-located central stations.

The relative cost of coal mined under union and non-union conditions will be the next study undertaken. The efficiency of labor in union mines, said Chairman Hammond, is alleged to be 50 or 60 per cent, as compared with 80 per cent in non-union mines.

That the Commission regards coal storage as of the greatest importance was reiterated by Mr. Hammond. An engineer has been assigned to investigate minutely the cost of local storage at the mines. The Commission regards the danger from spontaneous combustion as being so slight as to make unnecessary any further study of that phase of the question.

Water-Power Projects

Licenses and permits have been granted as follows:

The San Gorgonio Power Co. has received a license for power development by water diverted from Whitewater River to the San Gorgonio River. The project lies within the Angeles National Forest, California. Two power houses of 2,250 and 1,125 hp. will be built on the San Gorgonio. The entire output will be sold to the Southern Sierras Power Co.

To the **Alabama Interstate Power Co.** a three-year preliminary permit has been granted for a project consisting of four dams and four power houses and involving practically the entire length of the Tallapoosa River in Alabama. The permit requires that if a license is issued the company will allow water to pass by its dams in such amounts as the Secretary of War may prescribe for the protection of navigation on the Alabama River, of which the Tallapoosa is a tributary. A capacity of 250,000 hp. is considered feasible. For distribution, the extensive transmission system of the Alabama Power Co., in the State of Alabama, will be used.

Thebo, Starr & Anderton, (Inc.), have been granted two preliminary permits, both for a period of two years. The first covers a project on the South Fork of the American River, near Placerville, Calif., consisting of a dam about 290 ft. high creating a reservoir with a capacity of a half million acre-feet. It is planned to build a power house of 25,000 hp. The other permit covers a project on the McCloud River, consisting of two dams and power houses located respectively 6 and 19 miles above its mouth. An installation of 200,000 hp. is contemplated.

To the **Clarion River Power Co.,** two preliminary permits have been awarded each for three years. One permit covers a project consisting of an arched concrete dam 245 ft. high, with spillway and power house, to be located on the Clarion River about two miles upstream from its confluence with Mill Creek, near Clarion, Pa. The other permit covers a similar dam 156 ft. high, about two miles above the mouth of the Clarion River. An installed capacity of 235,000 hp. for the two projects is anticipated. These projects are included in the general plan of de-

velopment of the river. The Clarion company recently received a license for a project on this river and preliminary construction is now under way. In connection with this, the company's application to raise the height of its proposed dam from 75 to 80 ft. was granted by the Commission. This change is made in order to adapt the pool level to the dam site of the company's project to be located near the mouth of Mill Creek.

New Publications

Elementary Internal Combustion Engines. Second Edition. By J. W. Kershaw. Published by Longmans, Green & Co., New York and London, 1922. Cloth; 4¾x7¼ in.; 207 pages; 117 illustrations. Price, $1.75.

The second edition of Mr. Kershaw's book on the internal-combustion engine includes considerable material on the oil engine which did not appear in the first edition. As a textbook for first-year classes in internal-combustion engineering this volume undoubtedly will find a large use. For the designer or operator of such machines there is little of interest, since the scope of the work is limited to elementary theory and brief descriptions of typical engines.

Engineering Inspection. By E. A. Alcutt, Associate Professor of Thermodynamics in the University of Toronto, and Charles J. King. Published by D. Van Nostrand Co., 8 Warren St., New York City. Cloth; 6½x9¾ in.; 187 pages; 85 illustrations. Price, $5.

This book is designed to meet the needs of chief inspectors, manufacturing executives and others who desire a broad acquaintance with the underlying principles of inspection and an outline of the various methods of testing raw materials, work in progress and finished machines. While written in the main from the British viewpoint and dealing chiefly with British standards, this book contains much of interest to American manufacturers. A chapter on material tests and specifications describes the more important testing machines. Other chapters cover the inspection of raw materials, material in process and finished material, while the subjects of gages and machine-shop inspection are given special attention. A special section is devoted to final tests on engines, pumps, etc. These include running, performance and acceptance tests.

Personal Mention

Charles R. Worthington, formerly local manager of the Michigan Gas and Electric Co., is now chief engineer of the Lee Paper Co., Vicksburg, Mich.

G. W. Akerlow, formerly of Port Arthur, Tex., is now with the Owens Bottle Co., Glassboro, N. J., as mechanical engineer.

M. H. Cutler, formerly of the Turner Construction Co. and the Morrison Skinner Co., has entered the organization of Stone & Webster as an engineer in the structural division.

Society Affairs

Toledo Section, A.S.M.E., will hear Louis W. Arny, of the Leather Belting Exchange, on Feb. 16 at the Chamber of Commerce.

Milwaukee Section, A.S.M.E., will hear Forest Nagler, hydraulic engineer of the Allis-Chalmers Co., on "The Cross-Flow Impulse Turbine, a New Type of Waterwheel for High Heads," at its meeting on Feb. 20 at Museum Hall.

Schenectady Section, A.S.M.E., will meet Feb. 20 at Edison Hall. Slides and motion pictures will illustrate a talk on "Recent Improvements in Locomotive Design," by Mr. Ashworth, of the American Locomotive Co.

Providence Section, A.S.M.E., will meet Feb. 16 at the Providence Engineering Society's rooms. Mr. Weisman, of G. E. Co., will speak on "Synchronous Motors."

Bridgeport Branch, A.S.M.E., will meet Feb. 15 at the Stratfield Hotel to hear N. B. Hoffman, of the Colonial Steel Co., on "The Manufacture and Treatment of Steel."

Coming Meetings

American Institute of Electrical Engineers, 29 West 39th St., New York City. Mid-winter convention at New York City, Feb. 14-17.

Universal Exposition of Inventions and Patents, Grand Central Palace, New York City, Feb. 17-22.

American Institute of Mining and Metallurgical Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 19-21.

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Pacific coast regional meeting at Los Angeles, Apr. 16-18; spring meeting at Montreal, Canada, May 28-31.

Society of Industrial Engineers; George C. Dent, 327 S. La Salle St., Chicago, Ill. Spring convention at Cincinnati, Ohio, Apr. 18-20.

American Association of Engineers, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

American Institute of Electrical Engineers, 29 W. 39th St., New York City. Annual convention at Swampscott, Mass., June 25-29.

American Society for Testing Materials; C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 25-30.

Business Notes

The Brown Hoisting Machinery Co., Cleveland, Ohio, has appointed the Mackintosh Engineering Co., Schofield Bldg., Cleveland, as its agents for the State of Ohio, with the exception of Hamilton County.

Stewart-Thill Co. is the new name of the **Walter L. Flower Co., St. Louis, Mo.,** district representatives of the Conveyors Corp. of America, Chicago. The personnel of the organization remains the same and offices will be continued at 312 South Eighth St.

Trade Catalogs

Stokers, Oil Burners, Pulverized Fuel Systems — International Combustion Engineering Corporation, 43 Broad St., New York City. The first general catalog, containing condensed descriptions of all of the International products.

Recorders—Uehling Instrument Co., Paterson, N. J. A 12-page folder explaining the use of the Uehling combined barometer and vacuum recorder and the Uehling CO_2 recorder and indicator.

"Salient Facts on Silent Gears"—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. A booklet on "Micarta" non-metallic gears and pinions, giving photographs and data describing their applications, tables of gear data, etc., and enabling the gear user to judge of their applicability to his machinery.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Jan. 29 1923	Feb. 5 1923
Pool 1,	New York	$5.25–5.75	$5.00–5.75
Smokeless,	Columbus	6.75–7.75	5.00–6.00
Clearfield,	Boston	4.00–4.75	3.50–4.25
Somerset,	Boston	4.25–4.85	3.60–4.25
Kanawha,	Columbus	3.15–3.40	3.00–3.35
Hocking,	Columbus	2.65–3.00	2.65–3.00
Pittsburgh No. 8	Cleveland	3.25–5.50	
Franklin, Ill.,	Chicago	3.75–4.00	3.75–4.00
Central, Ill.,	Chicago	2.75–3.00	2.75–3.00
Ind. 4th Vein,	Chicago	3.50–3.75	3.00–3.25
West Ky.,	Louisville	2.25–2.75	2.25–2.50
S. E. Ky,	Louisville	3.00–3.25	3.00–3.50
Big Seam,	Birmingham	2.25–2.50	2.25–2.50

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—Feb. 1, Port Arthur light oil, 22@25 deg. Baumé, 4¾c. per gal.; 30@35 deg., 5¼c. per gal., f.o.b. Bayonne, N. J.

Chicago—Feb. 6, for 24@26 deg. Baumé, $2.02 per bbl.; 32@36 deg., $5.56 per bbl. in tank car.

Philadelphia — Feb. 5, 26@28 deg. Baumé, Oklahoma, $1@$1.05 per bbl.; 30@34 deg., Oklahoma (group 3), 3@3¼c. per gal.; 16@20 deg. Seaboard, $1@$1.05 per bbl.

St. Louis—Feb. 5, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2 per bbl.; 26@28 deg., $2.10; 28@30 deg., $2.25; 32@36 deg., 5¼c. per gal. gas oil; 36@40 deg., 5¾c. per gal. distillate.

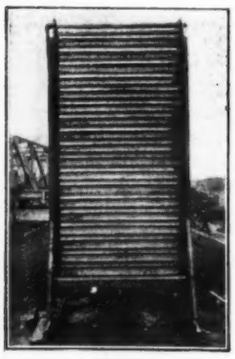
Pittsburgh—Jan. 9, f.o.b.. refinery, Penn., 36@40 deg., 5½@5¾c. per gal.; Kentucky, 26@30 deg., 4c.; Gas oil, 32@36 deg., 2¼@2¾c.; 36@38 deg., 2½@3c.; 38@40 deg., 90c.@$1.05 per bbl.

Dallas—Feb. 3, 26@30 deg., $1.28 per bbl.

Condensed-Clipping Index of Equipment

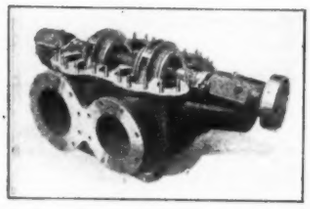
For quick reading and convenient filing

Tower, Small Cooling "Power," 1923
Edwin Burhorn Co., New York City



The "Smaltower" is a new type of cooling tower for plants where the water for cooling does not exceed 20 gal. per min. It is guaranteed to cool water from 90 to 80 deg. F. when the air is at 80 deg. and the humidity not over 70 per cent, and also to cool water under all similar atmospheric conditions to within 5 deg. of wet-bulb temperature. The tower is suitable for cooling the water from gas engines, air compressors, transformers, etc. A louvre system prevents the spilling of water even in heavy winds.

Pump, Series Centrifugal "Power," 1923
De Laval Steam Turbine Co., Trenton, N. J.



This "series," double-suction, multi-stage pump is in effect two (or three) single-stage pumps operating in series but built in the same casing. There are no diffusion vanes; the casing provides individual volutes for each impeller, with ample interconnecting passages within the casing itself. The use of a single casing eliminates two stuffing boxes between stages. Labyrinth wearing rings prevent leakage from discharge chambers to suction chambers, while leakage from stage to stage is prevented through the use of an extra-long bushing. A high efficiency is maintained over a wide range of delivery.

Fuse, Knife-Blade Renewable "Power," 1923.
Bussman Manufacturing Co., St. Louis, Mo.

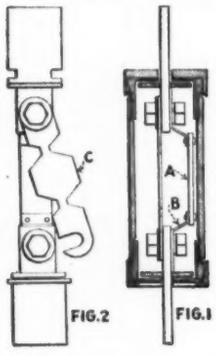
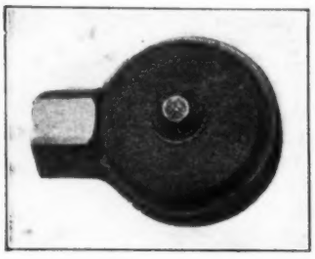


FIG.2 FIG.1

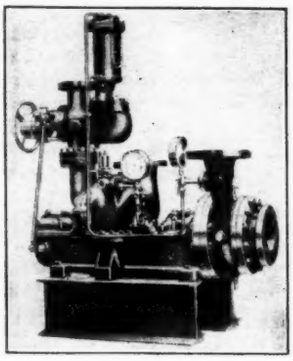
In the "Buss" renewable fuse the two terminals are permanently held together by fiber bar *A* and brass jumpers *B*. The renewable link *C* is slotted at each end; thus it is quickly inserted by loosening the bolts. When the fuse is blown, only the narrow sections of the link burn out, so that a pressure great enough to burst the case is not developed, and there is no need for an arc-extinguishing filler. There is just enough venting at the ends to permit escape of the gases, at the same time retaining sufficient pressure to extinguish the arc. Further described on page 528 of "Power" for Oct. 3, 1922.

Filter, Flue-Gas "Power," 1923.
Uehling Instrument Co., Paterson, N. J.



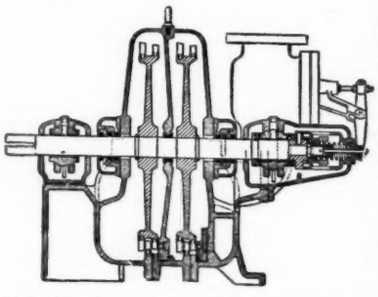
The "Pyro-Porus" gas filter completely excludes soot and dirt from the gas sampling line. It consists of two heavy but highly porous disks, mounted in a ring-shaped casting. It is inserted in the flue or last pass of the furnace, the disks possessing the refractory qualities needed to resist high temperatures. The use of this filter does away with the blowing out of gas lines so often necessary when cotton waste is used to filter the gas. The disks are low in cost and easily replaced.

Pump, Turbo Feed "Power," 1923.
Bethlehem Shipbuilding Corp., Ltd., Bethlehem, Pa.



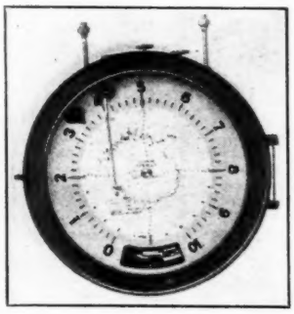
In the Bethlehem-Weir turbo feed pump, a single-stage, high pressure rotary pump is direct connected to an impulse turbine having one pressure and several velocity stages. Variations in boiler-feed pressure and in pump-discharge pressure are controlled by a hydraulic governor. A safety governor shuts off steam when the speed exceeds the maximum for specified operating conditions.

Turbine, Impulse Steam "Power," 1923.
Standard Turbine Corp., Wellsville, N. Y.



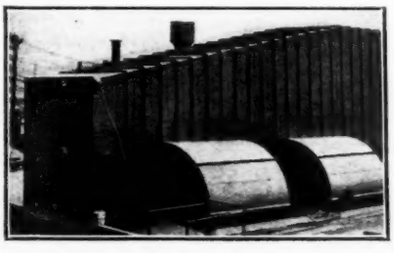
Of a closely standardized design, this turbine is built in sizes up to 600 hp. The upper half of the casing is in one piece and has no nozzles or blades in it and no machine work except joint facing and faces for the packing glands, which contain carbon rings. The governor is of the centrifugal type. An emergency governor functions when the normal speed is exceeded by a predetermined amount — usually 10 per cent. Although there is theoretically no end thrust, a thrust bearing is provided to take care of conditions, such as clogging of blades with foreign matter, that might produce end thrust.

Meter, Flow "Power," 1923
H. S. B. W.-Cochrane Corp., Philadelphia, Pa.



A mechanical flow meter for indicating and recording the flow of liquids or gases in pipes. From the high- and low-pressure sides of a sharp-edged orifice in the pipe line, leads are run to the two arms of a U-tube mercury manometer suspended on a knife-edge inside the casing of the instrument. The tilt of the U-tube is made proportional to the flow, through the use of a compensating cam and weight, and is transmitted to the indicating pointer and recording pen through sectors and pinions. Uniform divisions on the indicating and recording scales are obtained. There are no stuffing boxes, and the pressure connections to the orifice plate are carried through the plate itself, thus locating the openings permanently and correctly. Further described on page 570 of "Power" for Oct. 10, 1922.

Stiffener, Expansion, for Breeching "Power," 1923.
Connery & Co., Inc., Second St. above Erie Ave., Phila., Pa.



A new construction is shown for flues, breeching and other sheet-metal work subject to expansion and contraction due to marked temperature changes. Designed to eliminate warping and buckling, the expanding section is made of soft open-hearth plate, crimped cold in the form of a projecting rib, like that of an accordion bellows. It extends completely around the flue. Special pieces are electrically welded to make a tight joint at each corner. This construction prevents sagging, eliminates cumbersome expansion joints and produces a solid, air-tight uptake. See "Power" for Jan. 2, 1923, page 30, for further description and a sectional drawing of the expansion element.

For a permanent file of new and improved power-plant equipment, clip and paste on 3 x 5-in. cards. (Patented Aug. 20, 1918.)

New Plant Construction

PROPOSED WORK

Ark., Highland—Bert Johnson Orchards, Inc., are in the market for boilers and equipment for boiler house, to replace that destroyed by fire.

Ark., Van Buren — The city is receiving bids for remodeling water plant on Lee Creek, including 2 centrifugal pumps, 2 triplex pumps and rebuilding of present reservoir. W. L. Winters, 700 South 20th St., Fort Smith, Engr.

Calif., El Monte—The city, B. Moore, Clk., will receive bids until Feb. 15 for furnishing one centrifugal booster pump to deliver 900 g.p.m. against head of 160 ft.; also for one 50 hp. horizontal connected 40 degree motor.

Calif., Fall River Mills—The Fall River Irrigation District, S. McArthur, Trustee, Mills Bldg., San Francisco, is having plans prepared for the construction of 2 additional pumping plants. F. H. Tibbetts, Alaska Commercial Bldg., San Francisco, Consult. Engr. Noted July 18.

Calif., Hanford—The city received bids for furnishing two No. 7 single stage raw sewage pumps with 2 motors, 10 hp., 720 r.p.m., 3 phase, 220 volt with hand compensators, from Horlock-Clow Co., Hanford, $1,400; Wilson, Oran & Sanders, Visalia, $1,301 and $1,500 respectively; A. Berschig, Hanford, $1,416.

Calif., Montebello—The Montebello Irrigation District is having plans prepared for the construction of an irrigation system, including the installation of 53,000 lin.ft., 4 18 in. riveted steel pipe; two deep well turbine pumping plants, capacity 100 sec. ft.; 250,000 gal. steel tank. Estimated cost $125,000. Olmsted & Gillelen, Hollingsworth Bldg., Los Angeles, Engrs.

Calif., Napa—The city will receive bids until Feb. 26, for the construction of Milliken Dam, to be single arch concrete type, with maximum height of 112 ft. and approx. length 600 ft. to store 636,000,000 gals. A. Kempkey, Hobart Bldg., San Francisco, Consit. Engr. Noted Sept. 5, 1922.

Calif., Pasadena—The city, C. W. Keiner, City Mgr, plans to extend its generating plant and will soon receive bids for the purchase of $300,000 worth of additional equipment to generate 16,000 hp. The present city steam plant produces 10,000 hp.

Calif., Turlock — The Central California Ice Co., Mono and P Sts., Fresno, plans to build an ice plant, capacity 30,000 ton per day, on South 1st and D Sts., here. Estimated cost $45,000.

Conn., East Norwalk (South Norwalk P. O.)—Crofut & Knapp, Water and Tolles Sts., South Norwalk, are having plans prepared for the construction of 2, 3, and 4 story factory buildings for the manufacture of hats. Estimated cost $800,000. Fletcher Thompson, Inc., 542 Fairfield Ave., Bridgeport, Archts. and Engrs. Equipment detail not reported.

Ill., Chicago — D. H. Burnham & Co., Archt., 209 South La Salle St., is preparing plans for a 20 story, 162 x 181 ft. office building, including steam heating system, on Randolph and La Salle Sts. Estimated cost $8,000,000. Owner's name withheld.

Ill., Chicago—The Central Furniture Market, c/o G. C. Nimmons, Archt., 122 South Michigan Ave., plans the construction of a 12 story, 50 x 140 ft., office building, including steam heating system, at 1416 Wabash Ave. Estimated cost $500,000.

Ill., Chicago—The Chicago Beach Hotel Co., 1600 Hyde Park Blvd., plans the construction of an 8 story, 100 x 200 ft. garage, including steam heating system, on Hyde Park Blvd. Estimated cost $500,000. G. C. Nimmons, 122 South Michigan Ave., Archt.

Ill., Chicago—Graham, Anderson, Probst & White, Archts., 82 East Jackson Blvd., are preparing plans for the construction of a 16 story, 157 x 160 ft. office building, including steam heating system, on Canal St. near Jackson St. Owner's name withheld. Estimated cost $7,000,000.

Ill., Chicago—A. L. Himelblau, Archt., 127 North Dearborn St., is preparing plans for the construction of three 3 story, 136 x 390 ft. apartment buildings, including steam heating systems, on Addison Ave. near Glenwood St. Owner's name withheld. Estimated cost $600,000.

Ill., Chicago—H. J. Liedberg, Archt., 154 West Randolph St., is receiving bids for the construction of a 3 story, 150 x 390 ft. apartment building, including steam heating system, on Sheridan Rd. near Grace St. for A. Wille, c/o Archt. Estimated cost $800,000.

Ill., East St. Louis—The St. Clair Hotel Co., c/o A. T. Spiver, 511 Missouri Ave., is having plans prepared for the construction of a 6 or 7 story, 130 x 145 ft. hotel on Missouri Ave. Estimated cost $600,000. H. L. Stevens & Co., 30 North Michigan Ave., Chicago, Archts. Equipment detail not reported.

Ind., Crawfordsville—R. R. Donnelley & Sons Co. will soon award the contract for the construction of a 1 story printing plant. Estimated cost $1,000,000. H. Shaw, 39 South State St., Chicago, Archt. Noted Jan. 9.

Ind., Mishawaka — Burns & McDonnell, Engrs., Institute Bldg., Kansas City, Mo., will receive bids until Feb. 19, for the construction of a 1,500,000 gal. reservoir, including motor driven pumps, (centrifugal unit) for the Bd. Pub. Wks. Noted Oct. 31, 1922.

Ind., Sullivan — The Vigo Mining Co., Ross Dispensary Bldg., plans the construction of a 55 x 80 ft. power house, including equipment. Estimated cost $85,000. Shourds Stoner Co., Tribune Bldg., Terre Haute, Engrs.

Ia., Davenport — The city plans waterworks improvements, including tank, tower, mains, valves, hydrants and pumps. Estimated cost $20,000. Prince-Nixon Eng. Co., 501 Peters Trust Bldg., Omaha, Neb., Engrs.

Ky., Marion — The Kentucky Fluorspar Co. is in the market for two 150 hp. tubular boilers.

Md., Baltimore — Wyatt & Nolting, Archts., Keyser Bldg., are preparing plans for the construction of a 9 story, 192 x 241 ft. apartment house, including vacuum or vapor heating system and refrigeration plant, on University Parkway. Owner's name withheld. Estimated cost $800,000.

Mich., Clawson—The Village, A. C. Hodges, Clk., will receive bids until Feb. 14th for the construction of a pump house and furnishing and installing one 75 gal. per min., two stroke, deep well pump with electric motor to pump against a head of 215 ft. Ruhling, Holdsworth & Hudson, 16549 Woodward Ave., Highland Park, Engrs.

Mich., Detroit—M. H. Finkel, Archt., 919 Majestic Bldg., is receiving bids and will open same about Feb. 15 for the construction of an 11 story, 100 x 120 ft. apartment building, including vacuum steam heating plant and refrigerating plant, on Cass Ave., for H. Silverman, 1030 Penobscot Bldg.

Mich., Detroit—The Bd. Educ., 1354 Bway., plans the construction of a 3 story high school, including steam heating equipment, Plenum system, on Boston Blvd. Estimated cost $1,000,000. This is to be one unit of group to cost $10,000,000. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Archts.

Mich., Pontiac — P. R. Rossello, Archt., 406 Congress Bldg., Detroit, plans the construction of a 10 story, 120 x 140 ft. hotel building, including steam heating system. Estimated cost $450,000. Owner's name withheld.

Mich., St. Joseph — Cahill & Douglas, Engrs., 217 West Water St., Milwaukee, Wis., are receiving bids for 1 single valve automatic engine, one 110 hp. uniflo engine and two 62½ kva. generators, for the Whitcomb Hotel Co.

Miss., Columbus — The State Board Improvement Comn., Box 636, Jackson, will receive bids until Feb. 24 for steam heating plant, including stoker with hopper fronts for 250 hp. boilers, two sets of rotating seat blowers, one open type feed water heater, one outside packed plunger ram pattern boiler feed pump, one steel breeching for boilers, for the Mississippi State College for Women, here.

Mo., Glasgow—A. T. Archer & Co., Engrs., plan the construction of a new water works and sewer system, including equipment. Estimated cost $75,000 to $100,000.

Mo., Kansas City—Rush & Willett, 507 Lathrop Bldg., are having preliminary plans prepared for the construction of an 8 story hotel and apartment building on Valentine Rd. and Bway. Estimated cost $500,000. Lodge & Gornall, 1505 Commerce Bldg., Archts.

Mo., St. Louis—The Bd. Pub. Serv. will receive bids until Feb. 23, for the construction of a 2 story, 54 x 225 ft. combination service building and power house for the St. Louis Training School for Feeble Minded, at Scott Farm. Estimated cost $115,000. L. R. Bowen, 301 City Hall, Archt. and Engr. Power plant equipment will be purchased later.

Mo., St. Louis—R. K. Kaufman, c/o Mercantile Trust Co., 721 Locust St., will receive bids until Feb. 15th for the construction of a 3 story, 125 x 150, theatre and stores building on Washington Ave., for M. Loew, 1540 Bway., New York. Estimated cost $1,000,000. T. W. Lamb, 644 Eighth Ave., New York, Archt. Equipment detail not reported.

Neb., Lindsay—P. Shad, City Clk., will receive bids until Feb. 16, for a 50,000 gal. steel tank with 100 ft. tower and one 2 stroke deep well pump, 125 gal. per min., valve fittings, etc. Estimated cost $15,000. Henningson Eng. Co., 3rd Floor, Nat'l. Bldg., Omaha, Engrs.

Neb., Omaha—The B.P.O.E. No. 38, 4th floor, Elks Bldg., received bids for the construction of an 8 story, 132 x 132 ft. club building on 18th and Dodge Sts., general construction, Vaughn Constr. Co., 322 W. O. W. Bldg., Omaha, $509,462; C. F. Hagelin & Co., Minneapolis, Minn., $521,600; F. P. Gould & Son, 1137 City Natl. Bank, Omaha, $555,800; heating and ventilating apparatus, J. J. Hanighn Co., 617 South 14th St., low at $128,511; J. P. Daly, 16th and Capital Sts., low on cost plus basis at $124,000; electrical machines and apparatus, H. Binder, 1816 Havney St., $13,800. Noted Jan. 9.

Nev., Gerlach—The Pacific Portland Cement Co., Pacific Bldg., San Francisco, Cal., is receiving bids for materials and supplies for a townsite for cement-plant, including hotel, cottages, auditorium, power plant and tramway. Weeks & Day, Calif. Ins. Bldg., San Francisco, Archts. and Engrs.

N. J., Paterson—Alexander Hamilton Hotel, c/o Guilbert & Betelle, Archts and Engrs., 2 Lombardy St., Newark, is having plans prepared and will soon receive bids for a hotel. Estimated cost $1,000,000. Equipment detail not reported.

N. Y., Buffalo—The Hendon Chemical Co., c/o Williams, Minard & Williams, Erie Co. Bank Bldg., plans the construction of a chemical plant. Estimated cost $1,000,000. Architect not selected.

N. Y., Syracuse—The Crouse Irving Hospital, 720 South Crouse Ave., plans the construction of a power plant, including two 150 hp. engines and 150 hp. generator. Estimated cost $40,000. Gaggin & Gaggin, University Bldg., Engrs.

N. C., Goldsboro—The Carolina Power & Light Co., P. A. Tillery, Genl. Mgr., plans the enlargement of 60,000 volt substations at Goldsboro, Selma and other points.

N. C., Hickory—J. D. Elliott plans the construction of a dam, 65 ft. high, on Catawba River, 3 mi. from Hickory, known as the Thornton power site, to develop 33,000 hp.

N. C., Raleigh—The North Carolina State College, W. C. Riddick, Pres., plans the construction of buildings, purchase of equipment for vegetable oil, textile and furniture manufacturing departments and the extension of steam plant, sewers, etc. Estimated cost $1,000,000.

N. D., Fargo—The North Dakota Agricultural College is in the market for a mechanical stoker. Estimated cost $8,250.

Ohio, Greenville—The School Bd. will receive bids until Feb. 15, for the construction of a 3 story, 150 x 175 ft. high school, including steam heating system. Estimated cost $600,000. W. B. Ittner, Bd. Educ. Bldg., St. Louis, Mo., Archt. Noted Jan. 2.

Okla., Depew—The city is having plans prepared for the construction of a pumping station, water main and sewer system. Estimated cost $50,000. Gantt & Baker, First Natl. Bank Bldg., Oklahoma City, Engrs.

Okla., Weatherford—The city voted $100,000 bonds for the construction of a 500 hp. power plant, deep well pumps and a 20 ton raw water ice plant. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engrs. Noted Jan. 23.

Ore., Astoria—The Crystal Ice & Storage Co., G. W. Weathersby, Pres., 427 East Main St., Portland, plans the construction of a 1½ story, 50 x 80 ft., ice cream plant. Camp & DuPuy, Inc., 424 East Alder St., Portland, Archts. Owner is in the market for refrigerating machinery, engine, boiler, milk cooler, etc.

Ore., Nekoma (Mapleton P. O.)—H. E. Poe is in the market for a boiler, engine and new saw mill machinery.

Ore., Williamette—A. Leisman is in the market for a 50 hp. D.C. motor and an 8 x 8 in. air compressor.

Pa., Chambersburg—D. P. Minick, 147 East Queens St., is receiving bids for the construction of a 3 story, 40 x 115 ft. ice and cold storage plant, including power house on East Queens St. Estimated cost $75,000. J. Crowe, Hartman Bldg., York, Archt. Owner is in the market for ice and cold storage plant machinery.

Pa., Harrisburg—The Penn-Harris Hotel, c/o W. L. Stoddart, Archt., 9 East 40th St., New York, will soon receive bids for the construction of a hotel, here. Estimated cost $500,000. Equipment detail not reported.

Pa., Hazleton—G. B. Markle, 227 East Broad St., is having plans prepared for the construction of a 9 and 10 story, 95 x 150 ft. hotel on Broad and Church Sts. Estimated cost $2,000,000. Thomas, Martin & Kirkpatrick, Otis Bldg., Phila., Archts. Noted Aug. 22.

Pa., Hazleton—The Hazleton Natl. Bank, c/o D. C. Kunkel, is having plans prepared and will soon receive bids for the construction of a 5 story bank and office building. Estimated cost $500,000. Thomas, Martin & Kirkpatrick, Otis Bldg., Phila., Archts. Equipment detail not reported.

Pa., Middletown—The Independent Order of Odd Fellows, 17th and Tioga Sts., Phila., is receiving bids for the construction of a 3 story, 38 x 229 ft. Odd Fellows Home, with two wings, 33 x 154 ft., here. Estimated cost $750,000. W. H. Lee, 32 South 17th St., Phila., Archt. Equipment detail not reported.

Pa., New Castle—The Carnegie Steel Co., G. A. Rigby, Supt., is in the market for modern boilers and equipment for completely remodeling its boiler house.

Pa., Phila. — Oppenheim, Collins & Co., 1207 Chestnut St., plans the construction of 6 story, 48 x 230 ft. store and office building at 1126 Chestnut St. Estimated cost $500,000. Buckman & Kahn, 56 West 45th St., New York, Archts. Equipment detail not reported.

Pa., Phila. — E. Towsen, Norris Bldg., plans the construction of a 4 story apartment building at 43rd and Spruce Sts. Estimated cost $500,000. Hulme, 1523 Chestnut St., Archt.

Pa., Phila.—The University of Pennsylvania, 34th and Spruce Sts., plans the construction of an auditorium, club house and power plant. Estimated cost $3,000,000. P. E. Cret, 1512 Chestnut St., Phila., Archt.

Pa., Phila.—J. T. Windrim, Archt., Commonwealth Bldg., is receiving bids for the construction of a 2 story, 83 x 104 ft. substation on Trenton and Turner Sts. for the Phila. Electric Co., 10th and Chestnut Sts. Estimated cost $150,000. Equipment detail not reported.

S. C., Mullins—W. A. Gray is in the market for a 10 hp. engine and a 15 hp. boiler.

Tex., Sherman—The Diamond Ice Co. is having plans prepared and will soon receive bids for the construction of a 2 story, 52 x 120 ft. ice plant. Estimated cost $100,000. Engineer not announced.

Wash., Seattle—The Shafer Bros. Land Co., Arcade Bldg., is having plans prepared for the construction of a 10 story, 53 x 120 ft. office and store building on 6th and Pine Sts. Estimated cost $500,000. J. E. Blackwell, 112 Harvard St., N., Archt. Equipment detail not reported.

W. Va., Charles Town—C. Wainwright is in the market for an ice making machine (used).

W. Va., Huntington—The Union Savings Bank, 9th St., is having plans prepared for the construction of a 2 story, 44 x 78 ft. bank and office building on 4th Ave. and 9th St. Estimated cost $500,000. Meanor & Handloser, Robson & Pritchard Bldg., Archts.

W. Va., Kenova—The Consolidated Light, Heat & Power Co., Huntington, is in the market for a 15,000 kw. turbo generator for plant here.

Wis., Madison—W. A. Bakie, 916 East Johnson St., is in the market for refrigeration and laundry equipment for new store and apartment building.

Wis., Madison — The city received bids for air lift equipment and pump, complete with Booster tank for city water supply, from Indiana Air Pump Co., 812 Indiana-Pythian Bldg., Indianapolis, Ind., $1,592, alternate, $1,242; Wisconsin Fdry. Co., 623 East Main St., $2,185, alternate, $2,120; Harris Air Pump Co., 431 South Dearborn St., Chicago, $1,816, alternate, $1,169. Noted Jan. 30.

Wis., Platteville—The Farmers' Consumers' Exch., A. Benedict, Mgr., plans the construction of a 2 story, 50 x 60 ft. cold storage and refrigeration plant. Estimated cost $75,000. Architect not selected.

Wis., Racine—C. Nelsen, 1010 13th St., manufacturer of dairy products, is in the market for ice making machinery.

Wis., Sheboygan Falls—The city, C. Herman, Clk., is having plans prepared for a sewage system, including 8 and 10 in. sewers, about 10,000 ft. 6 in. c.i. water mains, new well and auxiliary pumping unit, compressed air with centrifugal pump, in Park, Main, Detroit, Chicago, Adams, Hickory and Washington Sts.

Ont., Oakwood—The Twp. Mariposa, J. B. Weldon, Clk., passed a bylaw to install a hydro electric power system throughout the township.

Que., Dane — Thompson & Chadbourne, J. B. Thompson, Purch. Agt., are in the market for a complete steam plant for mine development.

Que., Montreal—Montreal Insurance Exchange, c/o Greenshields, 120 St. James St., will soon receive bids for the construction of a 10 story, 85 x 110 x 190 ft. office building on St. James and Notre Dame Sts. Estimated cost $3,000,000. Architect not announced. Equipment detail not reported.

Ont., Weston—The Water, Power & Light Comn. of Weston, A. G. Pierson, Supt., is in the market for a gasoline auxiliary pump in connection with waterworks system, probably 1,000 g.p.m., 3 stage centrifugal pump for fire purposes.

Ont., Whitby—The Pub. Utility Comn., c/o W. J. Luke, Chn., will receive bids until Feb. 22, for the construction of a water filtration system, including slow sand filters, centrifugal pumps, motors, gasoline engines, etc. Estimated cost $50,000. F. W. Thorold Co., Ltd., 54 Admiral Rd., Toronto, Consult. Engrs.

CONTRACTS AWARDED

Calif., Lodi—The city awarded the contract for pumps in connection with the proposed sewage disposal plant, to the Byron-Jackson Iron Wks., 55 New Montgomery St., San Francisco, $3,355; electric motors to the Fairbanks-Morse Co., 651 Mission St., San Francisco, $3,236; air compressors to Halloran & Golcher, Sharon Bldg., San Francisco $7,270; flow meters to the General Electric Co., Rialto Bldg., San Francisco, $1,460; filtrous plates to the General Filtration Co., 325 Cutler Bldg., Rochester, N. Y., $4,380; fine screens and clarifiers to the Dorr Co., 101 Park Ave., New York, N. Y., $4,570 and $6,620 respectively. The bids for Kewanee water system, 2,100 gal. per hr., are taken under further advisement. Noted Feb. 6.

Calif., Sonoma—The Mission Inn Corp., O. Klatt, Secy., c/o Golden Gate Ferry Co., foot of Hyde St., San Francisco, awarded the contract for the construction of a 2 story hotel, natatorium and mineral baths on Bigelow Ranch in the Valley of the Moon, here, to Lange & Bergstrom, Sharon Bldg., San Francisco. Estimated cost $500,000. Equipment detail not reported.

D. C., Wash.—The Bureau of Yards & Docks, Navy Dept., awarded the contract for the construction of an addition to refrigerating and cold storage plant at Naval Hospital, to Chatard & Norris, 304 Continental Bldg., Baltimore, Md. $20,130.

Ill., Chicago—The Chicago Mill & Lumber Co., 111 West Washington St., awarded the contract for the construction of a 2 story, 300 x 400, factory at 949 Elston Ave., to Mueller Constr. Co., 179 West Washington St. Estimated cost $500,000. Steam heating system will be installed.

Ill., Forreston—The Illinois Central R.R. Co., 135 East 11th Pl., awarded the contract for the construction of a gravel washing plant, including power house, here, to W. J. Zitterell & Co., Webster City, Ia. Estimated cost $200,000.

Mass., Uxbridge—The Uxbridge Worsted Co., Mendon St., awarded the contract for the construction of a power plant, with 1,500 hp. boiler rating and two 500 kw. turbo generating units, to G. P. Carver, Inc., 261 Franklin St., Boston. Estimated cost $20,000.

Mich., Mt. Clemens—The Bd. Educ. awarded the contract for the construction of a 3 story, 300 x 300 ft. high school on Cass Ave., to F. R. Patterson Constr. Co., 2631 Woodward Ave., Detroit. Estimated cost $600,000. Steam heating system will be installed. Noted Aug. 1, 1922.

Mich., River Rouge—The Ford Motor Co., Highland Park, awarded the contract for the construction of a 1 and 2 story, 150 x 300 ft. cement plant, including powdered coal plant and waste heat boilers, to the H. G. Christman Co., 315 Stevens Bldg., Detroit, Mich.

Minn., Chisholm—The Bd. Educ. awarded the general contract for the construction of a 3 story, 249 x 422 ft., junior high school, to Madsen Constr. Co., Builders' Exch., Minneapolis, $422,000. Steam heating system will be installed. Noted Nov. 28, 1922.

Mo., St. Louis—A. M. Cornwell, 111 North 7th St., will build a 6 story, 236 x 236 ft. apartment hotel on West Pine St. Work will be done by separate contracts under supervision of P. J. Bradshaw, Archt., International Life Bldg. Estimated cost $2,200,000. Equipment detail not reported.

Mo., St. Louis—The St. Louis University, Grand and West Pine Sts., awarded the general contract for the construction of a 3 story, 250 x 460 ft. high school building on Oakland Ave., to the L. P. Caldwell Co., Ity. Exch. Bldg. Estimated cost $500,000. Equipment detail not reported.

N. J., Avon by the Sea—W. H. Post, c/o H. R. Kenyon, Archt., 103 Park Ave., New York, awarded the contract for the construction of an apartment building on Lincoln Ave. to W. H. Lawson, 103 Park Ave., New York. Estimated cost $900,000. Equipment detail not reported.

N. J., Ocean City—Ocean City Hotel Co., c/o J. H. Suttin, awarded the contract for the construction of an 8 story, 34 x 150 ft. hotel building at 112th St. and Boardwalk, to D. A. McClellan, Drexel Bldg., Phila., $850,000. Equipment detail not reported.

N. Y., New York—The Bd. Educ., 500 Park Ave., awarded the contract for the construction of the George Washington High School on Audubon Ave. and 183 St., to J. T. Brady & Co., 103 Park Ave., $2,311,385. Steam heating system will be installed. Noted Dec. 12, 1923.

N. Y., New York—F. T. Ley & Co., 18 West 44th St., will build by separate contracts a 23 story office building on Liberty St. and Bway. Estimated cost $6,000,000. Harrett & Van Vleck, 8 West 40th St., Archts. and Engrs. Equipment detail not reported.

N. Y., Niagara Falls — The Bd. Educ. awarded the general contract for the construction of a high school, to Laur & Mack, 1400 College Ave., $534,596; heating and ventilating, to Danforth & Co., St. Louis, Mo., $60,375. Noted Jan. 23.

Ohio, Cleveland—The Allerton Cleveland Co., c/o J. S. Cushman, Pres., awarded the contract for the construction of a 16 story hotel on East 136th St. and Chester Ave. to Crowell & Little Constr. Co., 3751 Prospect Ave. Estimated cost $2,000,000. Steam heating system will be installed.

Okla., Morris—The city awarded the contract for the construction of an earthen dam, filter plant, pipe line and pumping machinery, consisting of triplex pump and 25 hp. oil engine, to the Sherman Iron Wks., 10 East Main St., Oklahoma City. Noted Jan. 23.

Pa., West View (Pittsburgh P. O.)—The West View Ice Co., 230 Park Ave., awarded the contract for the construction of a 2 story, 40 x 70 ft. ice plant on Perrysville Rd., to A. Friedrich & Sons, 3429 East St., Pittsburgh. Estimated cost $40,000.

Tex., Houston—The Houston Cotton Exchange awarded the contract for the construction of a 16 story board of trade and office building on Prairie and Caroline Sts., to The Don Hall Constr. Co., 613 Carter Bldg., $1,500,000. Equipment detail not reported. Noted Dec. 26, 1922.

Va., Richmond—The Life Ins. Co. of Va., 10th and Bank Sts., awarded the contract for the construction of an 11 story office building on 10th and Broad Sts. to the J.G. Wilson Co., Mutual Bldg., $900,000. Equipment detail not reported.

Ont., Toronto—The Toronto Transportation Comn., H. H. Couzens, Gen. Mgr., 35 Yonge St., awarded the contract for the construction of a 1 story, 452 x 467 ft., car repair shop and a 4 story, 117 x 336 ft. storehouse, including steam heating system, on Bathurst St. and Davenport Rd., to J. V. Gray Constr. Co., 541 Queen St. E., $1,335,000. Noted Jan. 16.

T. H., Pearl Harbor — The Bureau of Yards & Docks, Navy Dept., Wash., D. C., awarded the contract for a refrigerating and ice making plant at Naval Operating Base, to the Vilter Mfg. Co., 935 Clinton St., Milwaukee, Wis., $17,670.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances—Discounts on standard, lap weld boiler tubes down three points on Pittsburgh basing card of Jan. 23; warehouse prices, however, have not advanced in New York. Fire hose, 2½-in. coupled, up 5c. per ft., during month. Steel structurals, $3.29 as against $3.14 per 100 lb., delivered in New York. Cotton waste higher than month ago in both Cleveland and New York. Red and white lead rose ¾c. per lb. during month. Cold finished steel higher in New York and Chicago. Discounts on boiler fitting-up bolts reduced ten points since last month. Wrought steel pipe discounts down two points on Pittsburgh basing card of Feb. 3. In electrical supplies, conduit, elbows, couplings, cut-outs and flexible cord, all up 5 per cent. Rubber-covered copper wire advanced 7 per cent since January.

Declines—Although pipe and boiler covering discounts have increased from two to six points, and other asbestos products have dropped somewhat in price, there remains a possibility of heavy asbestos demand during the current year. Coal shortage has increased the demand for insulation materials; legislation for fireproof building materials is an important factor and much asbestos will be required for automobile brake-lining.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in., coupled		50c. per ft.
Common, 2½-in., 3-ply	1.00 per ft. list less 50%	

	Air	
	First Grade	Second Grade
¼-in., 3-ply, per ft.	$0.31	$0.22½

Steam—Discounts from List

First grade....40–10–5% Second grade....50% Third grade....50–10%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition....65% Best grade....60%

LEATHER BELTING—List price per ply, 12-in. wide, per lin. ft. $2.88

Grade	Discount from list
Medium	30–10%
Heavy	20–5–2½%

RAWHIDE LACING—For cut, best grade, 40%, 2nd grade, 50%. For laces in sides, best, 48c. per sq.ft.; 2nd, 43c. Semi-tanned: cut, 40%; sides, 48c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ½ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		40@45%
For low-pressure heating and return lines	4-ply	66⅔%
	3-ply	70%
	2-ply	72%

PORTLAND CEMENT—New York, $2.60@$2.70 per bbl. without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.29 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	10.00@13.00	13.00	11.25
Mixed	7.00@12.00	10.00	8.00

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13¼ x 20½
Chicago	10.00	13.00
New York	16.00	20.00
Cleveland	$32.00 per M.	$48.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.96	$1.01	$1.02

WHITE AND RED LEAD—Base price in cents per pound:

	Red—Current		Red—1 Year Ago		White—Current Dry or In Oil	White—1 Yr. Ago Dry or In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	14.25	15.75	12.25	13.75	14.25	12.25
25- and 50-lb. keg	14.50	16.00	12.50	14.00	14.50	12.50
12½-lb. keg	14.75	16.25	12.75	14.25	14.75	12.75
5-lb. cans	17.25	18.75	15.25	16.75	17.25	15.25
1-lb. cans	19.25	20.75	17.25	18.75	19.25	17.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	45%	60%	60%
Tinned	50%	60%	4½c. per lb.

Structural rivets, ¾ to 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb. o.

New York....$3.85 Chicago....$3.75 Pittsburgh....$3.00

Boiler rivets, same sizes:

New York....$3.95 Chicago....$3.85 Pittsburgh....$3.10

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$50@55
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	27@30
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	31@34
Magnesite brick: 9-in. shapes	net ton	70@75
Magnesite brick: 9-in. arches, wedges and keys	net ton	77@82.50
Magnesite brick: Soaps and spits	per ton	98@105
Silica brick: Chicago district	per M	48@50
Silica brick: Birmingham, Ala.	per M	48@50
Silica brick: Mt. Union, Pa.	per M	42@44
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	43@50
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	40@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	38@45
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	35@41
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	37@41
Chrome ore crude, 45@50%	net ton	20@23
Magnesite dead burn	net ton	38@40

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	42.00	49.00	36.00
(35% tin)	25.00	17.50	.....

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting and screw stock, per 100 lb. base	$4.05	$3.95	$3.75
Flats, square and hexagons, per 100 lb. base	4.55	4.45	4.25

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	64	52½	¾ to 1¼	34	19

LAP WELD

2	57	45½	2	29	15
2½ to 6	61	49½	2½ to 4	32	19
7 to 8	58	45½	4½ to 6	32	19
9 and 12	57	44½	7 to 12	30	17

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	62	51½	¾ to 1¼	34	20
2 to 3	63	52½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	55	44½	2	30	17
2½ to 4	59	48½	2½ to 4	33	21
4½ to 6	58	47½	4½ to 6	32	20
7 to 8	54	41½	7 to 8	25	15
9 to 12	48	35½	9 to 12	20	8½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2½	.23	.29	.23
2¾	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3½	.32	.47	.35
3¾	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1½ in. to 2 in. diameter, 5c. per cut. 2¾ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 45.00 (net)	$59.00(net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	35%	20%
Coils to 1,000 ft.	40%	25%
1,000 to 5,000 ft.	45%	30%
5,000 ft. and over	50%	35%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¾	$58.36	$63.72	$10.45	$11.66	$4.74	$5.12
½	58.36	63.72	10.45	11.66	5.54	5.98
1	74.14	81.37	13.75	15.33	7.91	8.54
1	106.02	116.73	20.35	22.69	10.29	11.10
1¼	143.45	157.94	27.12	29.95	14.35	15.42
1½	171.51	188.84	36.16	39.94	17.72	19.04
2	203.76	254.07	66.29	73.22	23.63	25.39
2½	364.86	401.71	108.48	119.82	33.36	36.18
3	477.13	525.32	289.29	319.53	50.65	54.43
3½	602.78	660.74	638.86	705.64	67.53	72.57
4	737.05	805.72	738.30	815.48	84.42	90.72

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.09	D. P. D. B.	$0.27
D. P. M. L.	.14	T. P. S. B.	.26
T. P. M. L.	.20	T. P. D. B.	.39
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Am
D. P. M. L.	$0.39	$1.26	$1.31
T. P. M. L.	.55	1.47	1.89
D. P. S. B.	.49	1.26	.....
T. P. S. B.	.92	2.10	.....
D. P. D. B.	.89	2.46	.....
T. P. D. B.	1.57	4.20	.....
T. P. to D. P. D. B.	1.05	2.88	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$20.94
No. 16 cotton reinforced heavy	27.45
No. 18 cotton reinforced light	18.19
No. 16 cotton reinforced light	22.57
No. 18 cotton Canvasite cord	15.43
No. 16 cotton Canvasite cord	17.91

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$.20	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package (500)	$2.70
0–30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.40	100	75	$0.60	$0.65	50
15	.35	.40	100	100	.75	80	24
25	.35	.40	100	150	1.00	1.10	24
40	.35	.40	100	200	1.30	1.40	24
50	.35	.40	100	300	1.90	2.00	24
60	.40	45	100				12
				500	2.75	2.90	12
				750	4.00	4.25	8
				1,000	4.50	4.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.17
Composition 2-piece attachment plug	.20
Swivel attachment plug	.12

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 7.08	$ 8.98	$11.25	$17.92
12	9.79	11.90	14.08	23.41
10	12.84	14.69	17.92	30.43
8	17.26	20.11	23.64	40.69
6	.....	.....	35.73	.....
4	.....	.....	48.15	.....
2	.....	.....	73.00	.....
1	.....	.....	97.55	.....
0	.....	.....	121.08	.....
00	.....	.....	143.67	.....
000	.....	.....	172.63	.....
0000	.....	.....	206.38	.....

SOCKETS, BRASS SHELL—

¾ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	15%
1-5th to standard package	27%
Standard package	42%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	25c. lb
Soldering paste, 2 oz. cans	$1.00 doz

ENCLOSED SWITCHES, KNIFE—Externally operated, 250 d.c. or a.c., N.E.C

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	25%
$25 to $50 list value	30%
$50 list value or over	35%